ANIMAL KEEPERS' FORUM

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Special Issue Dedicated to Chelonians

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MISSION STATEMENT
(Revised April, 2009)
American Association of Zoo Keepers, Inc.

The American Association of Zoo Keepers, Inc. exists to advance excellence in the animal keeping profession, foster effective communication beneficial to animal care, support deserving conservation projects, and promote the preservation of our natural resources and animal life.

ABOUT THE COVER

This months's cover features a Burmese mountain tortoise (*Manouria emys)* submitted by Adam Thompson of Zoo Atlanta. The mirror was placed for visual enrichment and the photo will accompany a future article by Nikki Bouwens of Zoo Atlanta in the *AKF Enrichment Options* column. Burmese mountain tortoises are known as one of the largest species of tortoise in the world, with body weights of close to 100 pounds. In the wild, they are found in India, Bangladesh, Myanmar (Burma), Thailand, the Malay Peninsula, Sumatra and Borneo. They are considered the most ancient genotype of tortoise still living, based on molecular and morphological studies. This is the only species of tortoise that lays eggs above ground in a nest, which the female constructs of leaf litter. The species is listed as endangered by the IUCN. *Source: chelonia.org*

To learn more about the endangered Chelonians of the world, a great source is the report from the Turtle Conservation Coalition titled *Turtles in Trouble: The World's 25+ Most Endangered Tortoises and Freshwater Turtles—2011 (turtlesurvival.org).* The report states that approximately half of the world's 300 species of turtles are threatened with extinction. "The turtle survival crisis is unprecedented in its severity and risk...without intervention countless species will be lost... Without concerted conservation action, many of the world's turtles and tortoises will become extinct within the next few decades." The Editors hope you enjoy this special issue of the *AKF* dedicated to Chelonians. We especially thank the authors for their hard work and their efforts in advancing the husbandry and conservation of these important species, and we thank the Turtle Survival Alliance (TSA) and Zoo Med Laboratories, Inc. for their assistance in creating this important issue.

Articles sent to *Animal Keepers' Forum* will be reviewed by the editorial staff for publication. Articles of a research or technical nature will be submitted to one or more of the zoo professionals who serve as referees for *AKF*. No commitment is made to the author, but an effort will be made to publish articles as soon as possible. Lengthy articles may be separated into monthly installments at the discretion of the Editor. The Editor reserves the right to edit material without consultation unless approval is requested in writing by the author. Materials submitted will not be returned unless accompanied by a stamped, self-addressed, appropriately-sized envelope. Telephone, fax or e-mail contributions of late-breaking news or last-minute insertions are accepted as space allows. **Phone (330) 483-1104; FAX (330) 483-1444; e-mail is shane.good@aazk.org**. If you have questions about submission guidelines, please contact the Editor. Submission guidelines are also found at: **aazk.org/akf-submission-guidelines/.**

Deadline for each regular issue is the 3rd of the preceding month.
Dedicated issues may have separate deadline dates and will be noted by the Editor.

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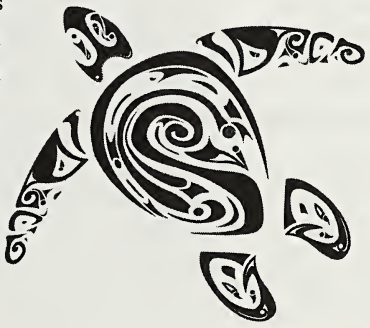
CHELONIANS

Turtles are some of the most easily recognizable animals.

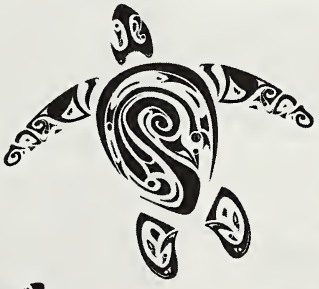
Because of their unique and distinctive shells, nothing else looks like them, and nothing else acts like them. That shell has served them well through more than 300 million years. Even though they were around to watch the dinosaurs come and go, they are having a tough time surviving in a world dominated by people, and are now the most endangered group of vertebrates on the planet.

Turtles that were once commonplace in remote habitats in far-flung corners of the world – in woods, streams, oceans, and even in our own backyards – are now disappearing at an alarming rate because of habitat loss and consumption for food. Turtles' slow-paced lifestyles and low reproductive rates make them particularly vulnerable to threats that other types of animals can overcome. As they decline, the populations that remain in zoos and private collections become ever more important, as do the dedicated people who care for them and champion them.

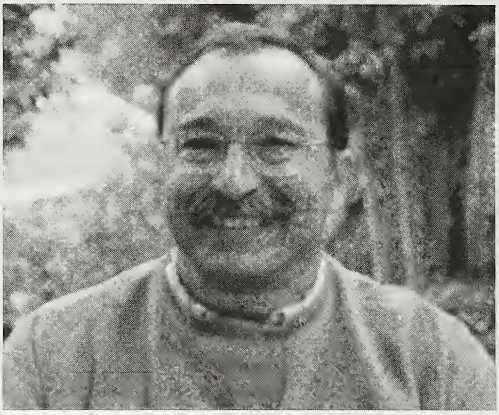
This issue of *Animal Keepers' Forum* features articles by some of those champions. I hope that you are encouraged to take a fresh look at these ancient creatures and think of ways to incorporate them into your collections and programming. AZA's Chelonian Taxon Advisory Group shares the distinction of having the most managed programs – and every one of those programs needs your help. You have the ability to make a difference.



Dwight Lawson, Ph.D.
Deputy Director
Zoo Atlanta



FROM THE PRESIDENT



We have all experienced an epiphany in our youth that in some way shaped our passion for animals. For me, it was the red-eared slider (*Trachemys scripta elegans*) that my parents brought home for me when I was in the third grade. The round plastic bowl with the fake miniature palm tree seemed inadequate for housing and I convinced my mom that a 20-gallon long aquarium would be more suitable. I added water, sand, a beach for sunning and a few guppies for company (I found out later that guppies became a food source in place of the flake source provided at the pet shop). What I quickly learned at such a young age was that my actions could dramatically affect the welfare of my red-eared friend. Today, that lesson is just as valuable as it was back when I was eight years-old.

In many cultures, turtles and tortoises are often depicted as symbols of longevity, endurance, stability, wisdom, and strength. In Asia, the Americas, Europe and Africa, these peaceful creatures of determination and tranquility have taken a prominent place among creation stories, often carrying the weight of the world upon its back.

Historically, charismatic mega-fauna, such as rhinos, lions, elephants, giant pandas and marine mammals have become flagship species for conservation education. Ask any child to name any of the large animals in the animal kingdom and chances are one of the afore-mentioned species will be named. While many conservation education strategies are based on these flagship species, much focus has been placed on chelonian counterparts: the Galapagos tortoise, desert tortoises and even sea turtles. Efforts to save chelonian species have taken on a global effort with programs covering the oceans, rivers and all forms of lowland terrain. Many of these efforts are sustained through conservation programs initiated by zoos and aquariums.

This dedicated issue of the *Animal Keepers' Forum* is long overdue. We focus much of our attention on mammalian charismatic mega-fauna. AAZK is pleased to finally bring to you a dedicated issue that focuses on chelonian conservation and husbandry. For me, this dedicated issue is a reminder that a simple connection at a young age can have profound results as an adult.

Bob Cisneros

— AAZK ANNOUNCES NEW MEMBERS —

NEW PROFESSIONAL MEMBERS

Jennifer Hurst, National Zoo, Washington (DC)
Ashlei Martin, Jacksonville Zoo, Jacksonville (FL)
Nikole Kirkpatrick, Nashville Zoo at Grassmere, Nashville (TN)
Kyle Chippy, Nashville Zoo at Grassmere, Nashville (TN)
Carl A. Mohler, Niabi Zoo, Coal Valley (IL)
Karla Grahn, Denver Downtown Aquarium, Denver (CO)
Claire Fukumoto, Honolulu Zoo, Honolulu (HI)
Kimberly Kessler, Honolulu Zoo, Honolulu (HI)
Elise Schembri, Toronto Zoo, Scarborough (Canada)
Kimberley Tovee, Toronto Zoo, Scarborough (Canada)

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Granite Industries, Archbold (OH)

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National Aquarium/Bio Programs, Baltimore (MD)

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EBSCO Publishing, Ipswich (MA)
Animal Source Texas, Inc., Krum (TX)

RENEWING CONTRIBUTING MEMBER

Tiffany Robben, Meriden (KS)

RENEWING INSTITUTIONS

Catoctin Wildlife Preserve & Zoo, Thurmont (MD)
Gulf Breeze Zoo, Gulf Breeze (FL)
Naples Zoo, Naples (FL)
Peoria Zoo, Peoria (IL)
International Exotic Feline Sanctuary, Boyd (TX)
Utah's Hogle Zoo, Salt Lake City (UT)

COMING EVENTS

Post Your Upcoming Events here — e-mail shane.good@aazk.org

July 25 - 28, 2012
The 35th International Herpetological Symposium
Hosted by Catoctin Wildlife Preserve and Zoo at the Ramada BWI Airport in Hanover, MD. For more information go to kingsnake.com/ihs.

July 29 - 30, 2012
The 2nd Venomous Animal Safety and Husbandry Training Seminar
Hosted by Catoctin Wildlife Preserve and Zoo in Thurmont, MD. For more information contact Rick Hahn at rickhahn@CWPZoo.com.

August 7th, 2012
Florida Animal Care Professionals Development Workshop:
Making your veterinarian happy – training aardvark to zebra for A.I. to ultrasound; operant conditioning training for voluntary cooperation in medical procedures.

Our inaugural workshop will be held Tuesday, August 7th 2012 from 4-8pm in Riley's Reserve at Tampa's Lowry Park Zoo. Refreshments and a light dinner will be served during each workshop. For registration information please e-mail FACPdevelopmentworkshop@gmail.com or call 813-935-8552 ext. 247.

August 8-14, 2012
The World Congress of Herpetology
To be held in Vancouver, Canada. For more information see worldcongressofherpetology.com.

August 16-19, 2012
The 10th Annual Symposium on the Conservation and Biology of Tortoises and Freshwater Turtles
Tucson, AZ. Hosted by the Turtle Survival Alliance and the IUCN Tortoise and Freshwater Turtle Specialist Group. For more information go to turtlesurvival.org.

August 20 - 23, 2012
2012 Orangutan SSP Husbandry Workshop
Location: Portland, Oregon • *Sponsor:* Oregon Zoo
Focus: This Orangutan SSP Husbandry Workshop will focus on the care and management of the orangutan in zoological parks and sanctuaries. The workshop will bring together orangutan caregivers and managers, researchers, and field biologists to share and disseminate the most current information on husbandry, conservation, and emergent issues pertaining to captive and wild populations of orangutans.
E-mail: jennifer.davis@oregonzoo.org
website: oregonzoo.org/orang2012

September 9-13, 2012
4th International Congress on Zookeeping
Sponsored by Wildlife Reserves Singapore/ Singapore Tourism Bureau. Theme: "Many Voices, One Calling". For info on sponsorship or exhibit opportunities e-mail eo@aszk.org.au. Check the ICZ website iczoo.org for latest news/information.

September 23-27, 2012
AAZK National Conference
Hosted by the Rosamond Gifford Zoo and the Rosamond Gifford Zoo AAZK Chapter in Syracuse, NY. For more information see rgzaazk.org.

October 12-15, 2012
From Good Care to Great Welfare: A Workshop Designed for Animal Care Professionals
For information contact: Elizabeth Arbaugh, Animal Welfare Manager, Detroit Zoological Society, Tel: 248-398-0903 x3643, E-mail: Elizabeth@dzs.org or visit czaw.org.

National Conferences

AZA
2012 - Phoenix, AZ - September 8-13
2013 - Kansas City, MO - September 7-12
2014 - Orlando, FL - September 12-17
aza.org

AAZK
2012 - Syracuse, NY - September 23-27
2013 - Asheboro, NC - September 22-26
2014 - Orlando, FL - September 8-12
aazk.org

A Brief Overview of Captive Husbandry of Turtles for Non-Reptile Keepers

Bill Hughes
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bhh@tnaqua.org

Blanding's turtles *(Emydoidea blandingii)* are an endangered species in North America. *Photo ©Shutterstock*

Exhibit space at zoological institutions is usually limited. Many species of turtles can be kept in the same enclosure with other types of animals such as birds or mammals without any serious risk. Displaying several species from the same part of the world in a single exhibit enhances the experience of zoo and aquarium visitors. Another benefit is that turtles may be active during the part of the day when the mammals are resting, thus preventing the perception that the exhibit is empty or boring. Some institutions transfer responsibility for the care of turtles housed with other species to non-reptile staff. This may be because of workload issues or distance from the rest of the herpetological collection. It may also be the most logical partition of staff resources as the keepers primarily responsible for a non-reptile exhibit containing turtles may have the easiest access to it. But zoo keepers who don't have any sort of background in reptile care may be intimidated by having to take care of animals with which they are not at all familiar. This article was written to provide some very general husbandry guidelines for those keepers.

The most important initial task to perform is research. Determine the scientific name of the turtle or turtles; the common name may help but it might also lead one astray. For example, Asian box turtles (*Cuora* species) have different care requirements than North American box turtles (*Terrapene* species). In fact, despite their shared common name, these turtles are not even in the same family. There are a tremendous amount of books and journals and magazines dealing with turtles, so it is easy to be overwhelmed by all the information. Focus on details that will help with captive care requirements.

A very important factor for keeping turtles successfully is temperature. Since turtles are poikilothermic (not cold-blooded – that term is not accurate and out-dated), the temperature of their environment directly impacts their health and behavior. Sunny exhibits may need to have some sort of cover such as mulch piles or logs for the turtles to get out of the direct sun and avoid overheating. Aquatic turtles regulate their body temperature by basking so providing logs or other potential basking areas is important. Lower temperatures may result in decreased activity and diminished appetite. Turtles may need to be moved indoors briefly for cold spells. If they are kept outdoors in an area that experiences winters with temperatures too cold for a given species, then they may need to be moved indoors for the entire season. The temperatures that turtles can tolerate vary considerably. Determining the optimal temperatures for the turtles in one's care will aid considerably in the husbandry of these animals.

Nutrition and attention to providing proper diets are other key factors to maintaining turtles successfully. Varied diets are important. At the Tennessee Aquarium most of the aquatic and semi-aquatic turtles get a commercial chelonian pellet as the bulk of their diet. The pelleted diet is augmented with various species-specific food items such as nightcrawlers, mice, mealworms, or fruit. Some aquatic turtles will not feed on pellets. The snake-necked turtles (*Chelodina*) at the Aquarium refuse to feed on anything but mice or live insects. Frequency of feeding varies. Juvenile turtles should be fed 3-4 times per week while adults may only need to be fed 2-3 times per week. When temperatures are lower, turtles in outdoor exhibits may feed very little or not at all.

Turtles may eat the diet of the other animals in the exhibit. This may be problematic as eating a protein source from an exhibit-mate's diet might lead to health problems with some tortoise species that have relatively low protein requirements. The Delta Country exhibit at the Tennessee Aquarium has a mixture of aquatic turtles, ducks, and fish. Feeding the turtles typically involves feeding the other exhibit animals as well. The ducks and fish eat the pelleted food with the same fervor as the turtles. Feeding extra is necessary to ensure that the turtles actually get fed enough.

There are some aspects of turtle reproduction that need to be kept in mind when working with these animals. Female turtles that are ready to lay eggs may become more active and may be in places in the exhibit they are usually not. Females observed in the process of laying eggs should not be disturbed as disturbance may cause egg retention (dystocia) or may cause the female to nest in a new (potentially undiscovered) location. If a female is observed nesting, try to find some sort of visual aid so that the nest can be found later when she is done. Some species may nest during the evening or other times when no one is there to observe the event. In this case, the nest may be visible because of signs of digging. Females of some species of turtle may dig several trial nests until a suitable nest site is located.

When a nest is excavated in order to remove the eggs for artificial incubation, it is important that the eggs not be rotated as this can damage them. Marking the tops of eggs with a permanent marker is a good way to keep this from happening. Containers with some of the substrate from the exhibit are a convenient way to temporarily store the eggs for transport. Making an indentation in the substrate for each egg will help prevent them from rotating while they are being transported.

Eggs may not be found when they are laid and babies may hatch in the exhibit. Knowing the average clutch size is useful in this situation. If the turtle in the exhibit typically lays two to three eggs at a time and six hatchlings are found, then there is a good chance there were two nests that were undiscovered. Many species nest at specific times of the year; knowing approximately when this happens means that one will have a better idea of when to expect nesting behavior. However, some species may nest at any time of the year and may be very good at concealing their nests. The Fly River exhibit at the Tennessee Aquarium contains rainbow fish, red-bellied sideneck turtles (*Emydura subglobosa*) and pig-nosed turtles (*Carettochelys insculpta*). The *Emydura* nest at night. Babies occasionally hatch in the early morning and if they are not found by staff before they enter the water, they are at great risk of being eaten by the *Carettochelys*.

Another important thing to determine is normal or expected behavior for a given species. Some turtles

(spiny turtles, *Heosemys spinosa*) are very sedentary and may not move from a given spot for days at a time. This sort of behavior in other species would be indicative of poor health. Some species are very shy (and may never be very active if they are aware of a keeper's presence) – such as Vietnamese box turtles (*Cuora galbinifrons*). For these two species, active females may be searching for a nesting site and active males may be searching for females. They may also be responding to environmental cues such as lower barometric pressure or warming temperatures. Exhibit social dynamics can change: animals that have lived together for years may become intolerant of each other. Some chelonians are slow-maturing and their behavior may be different once they are sexually mature. Some male turtles may perform combat with other male turtles (leopard tortoises, *Geochelone pardalis*). Overly enthusiastic males may injure

The pig-nosed a.k.a Fly River turtle (*Carettochelys insculpta)* is considered to be the freshwater turtle species most adapted to aquatic life. *Photo ©Shutterstock*

females; for example, male wood turtles (*Clemmys insculpta*) have been known to drown females during reproductive attempts. This sort of behavior may just suddenly start without warning.

The occasion will arise when the turtles need to be taken out of an exhibit. It may be a temporary move to winter housing or a permanent move to another exhibit. It may also just be time for an annual physical exam by veterinary staff. Whatever the reason, catching the turtles from an exhibit may require some teamwork. Aquatic turtles in large tanks may be difficult to capture. A deep tank might require the aid of a diver or the crafty use of some long-handled nets. Visually locating all (sometimes locating any!) of the turtles in the Aquarium's multi-story Nickajack Lake tank is very difficult as the tank has multiple viewing windows and many places for turtles to hide. Catching turtles from this tank is usually only possible by using Scuba gear. Turtles kept in exhibits with large or potentially dangerous animals may require the animals to be shifted off-exhibit before the turtles can be caught. The Tennessee Aquarium keeps an adult female American alligator and a trio of alligator snapping turtles in a mixed-species exhibit. Accessing the turtles with the alligator in the exhibit can sometimes be problematic. The alligator can usually be lured with food to an area where she can be isolated. Another thing to keep in mind is that turtles may be trapped at the drain when a moat is dropped or may become trapped by an exhibit prop. In these cases, there is a potential for drowning.

Keeping track of the turtles in an exhibit requires that individual animals can be easily identified. There are several common methods of identifying turtles. One such method is notching the marginal scutes of the carapace with a file. In order to avoid confusion and possible misidentification, the markings need to be unique for a given species of turtle (or at least all the representatives of that species in a single enclosure). Notches have the advantage of being easy to read and don't require any specialized equipment (such as a transponder reader). However, with time, some notches may become less discernible. Trauma to the shell of the turtle can also cause the notch to disappear or leave markings that look like notches.

Notching patterns can vary. Tennessee Aquarium herpetology staff notch at least one marginal on a turtle's right side as well as one on its left. This results in identifications such as 3L, 2R. Notching juvenile turtles is usually not recommended. Instead, smaller animals may be marked with nail polish. The disadvantage of this method is that the nail polish will eventually come off. Also, turtles marked with nail polish may not be considered visually appealing in an exhibit.

One of the best methods for identifying turtles is by using transponders. Assuming the transponder is inserted correctly, these devices provide a permanent means of identifying turtles. The main disadvantage is that there is no way to determine a turtle's identity without having a reader. A turtle usually needs to weigh 100 grams or more before inserting a transponder is considered safe. At the Tennessee Aquarium, the staff usually uses both transponders and notches. This provides a backup method should a transponder fail or a notch become unreadable.

Of course, notches, transponders and nail polish may not be necessary. If there is only one of a given species of turtle in an exhibit, identification should be pretty straightforward. If there is only a sexual pair of turtles in an exhibit, the afore-mentioned methods may also be redundant if the sexes of the turtles can be easily distinguished.

However, sexual dimorphism in turtles varies and there are no general rules. Males may be considerably larger than females (alligator snapping turtles, *Macroclemys temminckii*) or the females may be larger than the males (map turtles, *Graptemys* species). There may be a difference in pattern; for example, male eyed-turtles, *Sacalia,* have different head patterns than females. Males may have a plastral concavity (North American box turtles, *Terrapene*). Males may have an obviously longer and thicker tail than a female (black-breasted leaf turtles, *Geoemyda spengleri*). And keep in mind that young animals may not exhibit any of these features.

The hope is that the information presented here will help to make keepers with little or no reptile experience feel slightly better about taking care of turtles for which they may find themselves responsible. Turtles can make an interesting addition to an exhibit and the non-reptile zoo staff tasked with their husbandry will find that the husbandry of these animals will soon become part of their daily routine (and may even be the favorite part!).

Leopard tortoise (*Stigmochelys pardalis*). *Photo ©Shutterstock*

Bubba: A *Sulcata* on a Skateboard

By
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Abstract

Management of medical conditions in zoo animals can present unique challenges to veterinary and keeper staffs, often requiring creative solutions. The Sacramento Zoo was faced with the challenge of how to limit the use of a tortoise's limb while still allowing the animal to have mobility. While the use of carts for cats and dogs with spinal injuries are common, we took this idea and modified it creating a skateboard for a tortoise. This allowed us to treat and rehabilitate 1.0 *sulcata* tortoise known as "Bubba."

Natural History

The African spur thighed tortoise (*Geochelone sulcata)* is native to the northern region of Africa. They range along the southern edge of the Sahara within the countries of Senegal, Mauritania, Mali, Niger, Chad, the Sudan, and Ethiopia. The *sulcata* is the third-largest tortoise species, with a weight range of 80-150 lbs (36-68 kg), and an average carapace length of 24-30 inches (60-75 cm). They are the largest tortoise species from the African continent. The oldest *sulcata* on record lived to be 54 years-old (Hughes, 1986, in Stearns). *Sulcatas* are adapted to living in the dry grasslands with thick skin that is resistant to fluid loss in dry conditions; however when exposed to moisture, their skin may become permeable, allowing them to acquire what moisture they need. Like other desert-oriented tortoise species, the *sulcata* will excavate burrows to thirty inches in depth, and once underground, the burrow can then reach lengths of ten feet or more. As *sulcatas* are grassland tortoises, they obtain the majority of their nutrition from the grasses on which they graze. In captivity, they will readily eat assorted greens, yams, carrots, with occasional broccoli, squash, and tomatoes as relished treats.

The *sulcata* species is listed as vulnerable, though they are very common in the pet trade within the United States, despite the CITES Appendix II status. *Sulcatas* have developed a reputation as a "throw away pet", due to their large size and destructive tendencies. They can be purchased when they are newly hatched and sized to fit within a child's hands. *Sulcatas* grow quickly, are prone to digging large burrows, and as their weights increase, they become more than most people care to handle, and the owners often end up getting rid of the tortoises in any way they can. Zoos and rescue centers are regularly called by people wanting to donate their unwanted tortoises. In October 1999, the Sacramento Zoo acquired the subject of this paper when he was donated by a local veterinarian. As a result of the manner of acquisition, his date of birth and parentage are unknown. Based upon his size, keepers estimated the tortoise's age to be thirteen years.

Initial Medical Problem

Bubba has had an unremarkable medical history with an annual physical exam and radiographs bi-yearly. In 2010 a new tortoise exhibit located between the Giraffe exhibit space and the visitor viewing deck, (approximately 904 sq. ft.), was constructed in combination with the Tall Wonders Giraffe Encounter. The exhibit features a heated house that is approximately 81 sq. ft., while the exhibit yard is a mixture of grass and dirt with small boulders and tall grasses for decorative design. There is a slight slope up to the fence of the Giraffe yard. Bubba shares this exhibit with two smaller *sulcata* tortoises.

On 25 January 2011 (day 1 of presentation) keepers reported that Bubba had been showing signs of lameness for one day. He was not bearing full weight on his left front leg. Keepers were advised to monitor and report back to veterinary staff if the lameness persisted or worsened. On 31 January 2011 (day 1 of treatment) the lameness had increased to non-weight-bearing and a full physical exam was performed. During his exam, radiographs of the left front limb were taken and showed irregularities in the margins of the elbow and carpal joints consistent with osteoarthritis. The left distal humerus had areas of focal radiolucency, and a possible bone fragment. He was given an injection of Meloxicam, a non-steroidal anti-inflammatory (NSAID), for pain. Bubba was returned to his exhibit and keepers continued to monitor his lameness.

Medical Treatment

On 1 February 2011, Bubba was placed on oral Meloxicam every other day and Tramadol once daily. Tramadol is a synthetic opioid analgesic used to treat moderate to severe pain. While it was hoped that a combination of analgesics would help alleviate Bubba's pain, it was obvious two days later that his condition was not improving. He was moved to the Dr. Murray E. Fowler Veterinary Hospital. The hospital has a room dedicated specifically for sick birds or reptiles that can be modified to fit the specific needs of the animal hospitalized. In Bubba's case, he had free access to the entire room with a 250-watt radiant heater hung from the ceiling three feet off of the floor to give him a basking spot while the room temperature was set to maintain a range of 75 to 85 degrees Fahrenheit. Due to the concerns that there may be osteomyelitis in the leg and further use of the leg might worsen the condition, the staff wanted to keep Bubba from using or bearing weight on the front left leg. For most mammals this would be a bandage that brought the leg up to the body or a splint which restricted movement. These animals are able to ambulate without problem on three legs. Tortoises, however, require the use of all limbs to raise themselves and move. Turtles and tortoises must rely exclusively on movements of the limbs to propel themselves. The challenge was how to keep a 41kg tortoise off of a limb. The veterinary staff needed a device that would keep Bubba's weight off of his leg, but still allow him to move freely. The Maintenance Department was consulted and tasked with constructing a tortoise cart the following day while the veterinary staff performed a follow-up examination.

Due to the lack of improvement in the tortoise's condition, additional diagnostics were performed on 4 February 2011. This exam included a blood culture, arthrocentesis [or joint-tap (fig 2)],

Figure 2: Radiograph guided arthrocentesis

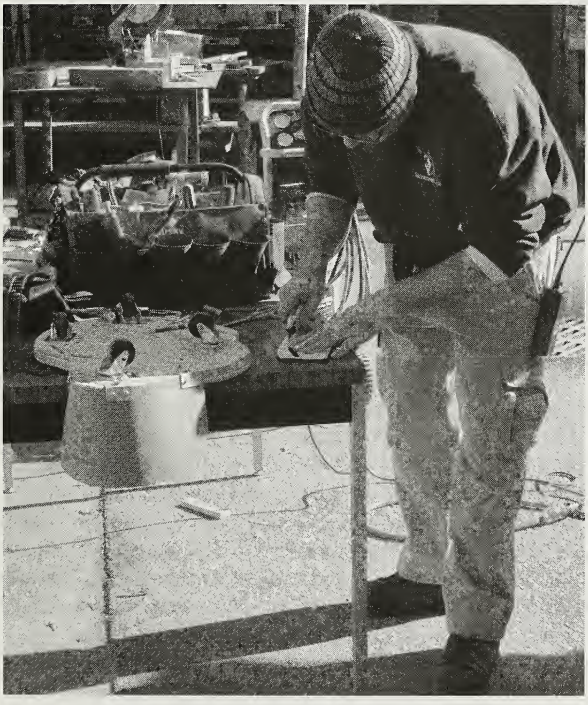

Figure 3: Ron Languasco making the cart

Complete Blood Cell count (CBC), blood chemistry panel, additional radiographs and obtaining an accurate body weight (41kg). Radiographs of the left front limb showed marked irregularity at the joint margins with areas of bony proliferations and lysis at the distal humeral condyl. These results were more consistent with osteomyelitis or neoplasia rather than trauma. The arthrocentesis results showed mild mononuclear inflammation most compatible with a degenerative joint disease. While under anesthesia, the maintenance department took measurements of Bubba and outlined the plastron using a towel and a black marker. The cart was constructed out of 1" plywood, four wheels and two nylon straps. The wood was cut to include a place for the left front leg to rest and all edges were rounded and smoothed. While Bubba recovered from anesthesia he was strapped onto the cart. After a few days of walking around on his new cart it was obvious that a few modifications were needed. Bubba was having a hard time reaching the ground with his back feet, the straps kept breaking, he was still able to use his front left leg and he was becoming very good at doing wheelies with his front right foot. The cart was taken back to our maintenance department where the rear wheels were sunk into the wood (to lower the back of the cart), a fifth wheel was added in the middle rear area, rubber padding was installed on the cart to prevent sliding, the straps were replaced with heavier nylon versions and a leg guard was placed on the front of the cart to keep the left leg from being able to bear weight (fig 3).

On 10 February 2011, Dr. Allison Zwingenberger, a Radiologist at the University of California at Davis Veterinary Medical Teaching Hospital (UCD VMTH), was consulted and agreed that the radiographic bone changes were likely the result of an infection. Bubba was started on

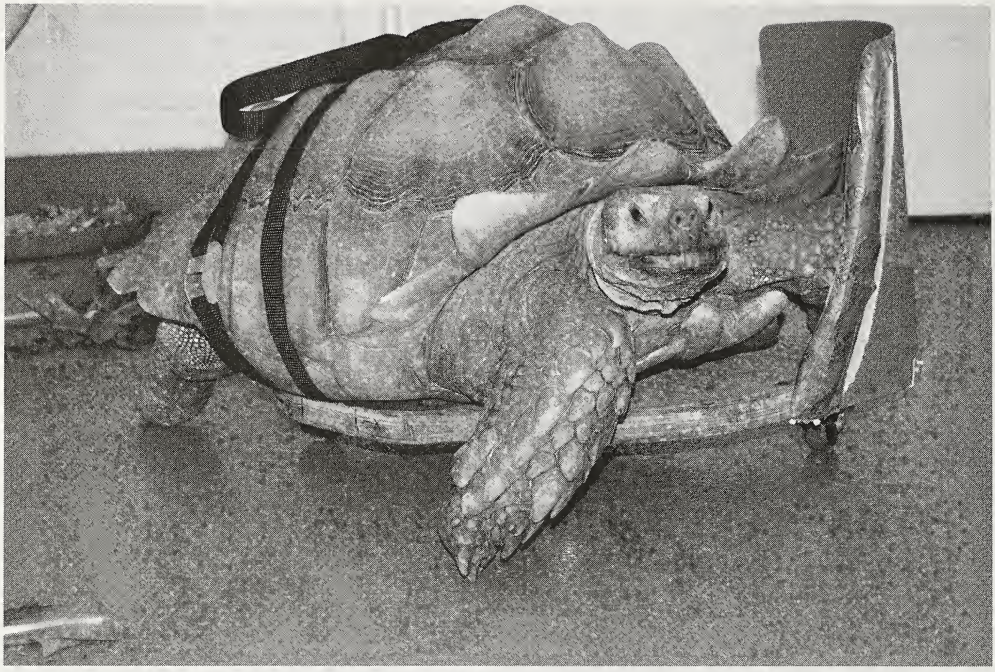

Figure 4: Bubba on the cart

Ceftazidime injections (three times a week), a broad spectrum cephalosporin antibiotic. Bubba's activity and appetite had decreased since he was placed on the cart and he had started to refuse all oral medications; as a result his oral Meloxicam treatment was changed to a daily injection. As he spent the majority of his time under the basking heater, veterinarians and the curator were asked about the possibility of giving Bubba some time outside on warm days. Permission was granted and he was allowed time outside behind the Veterinary hospital on days that were above 70 degrees Fahrenheit and sunny. On 13 February 2011 he spent his first 4 ½ hours outside with some supervised time spent grazing. This was the most active he had been in some time. He had figured out that the asphalt behind the hospital sloped slightly and he would walk up one end and slide down. This was only about five feet long, but he appeared to enjoy it. He also became very adept at climbing hills with his cart. The grassy area behind the hospital is a slight hill; using his three available legs he would climb the hill to get to his favorite patches of grass. He was allowed unsupervised time outside when he was confined to the asphalt, but had to be supervised when grazing in case he got stuck in mud or flipped over while climbing. (fig 4)

Bubba's appetite remained decreased, until it was discovered that by flipping his food dish over and offering his diet on top, (a difference in about two inches of height), Bubba was better able to reach his food and ate readily. Leaving his food this way was not practical as Bubba would knock the food off of the bowl and have difficulty eating it off the ground. Reptile keeper Bill Tabb was asked to make a raised food bowl. Using two plant saucers that were placed bottom to bottom and attached together with three screws, he devised a raised feeder. Bubba made his own modifications to the food bowl over the next week by pinning the food bowl against the wall with his cart. This cracked the top bowl and made an indentation in one side. The cracked piece was removed and edges of the food bowl were smoothed. This was the best spot for Bubba to eat his food (fig 5).

After three weeks of treatment, the leg guard was removed during the day. Veterinary staff wanted to assess the use of the limb without letting Bubba place full weight on it. He was observed letting

the leg rest on the cart multiple times throughout the day. While his leg appeared visibly swollen at the elbow joint, the swelling had decreased from the initial presentation. The leg guard was placed back on the cart the following morning and Bubba continued to improve on his cart.

Veterinary staff performed a follow-up examination 37 days into the treatment. The examination included repeat radiographs, arthrocentesis, CBC and blood chemistry panels. Over the previous five weeks of hospitalization his weight had remained steady and appetite returned to normal. He was anesthetized for the examination. Contracture of the muscles around the left elbow was appreciated. There was resistance to the manipulation of the joint and no appreciable crepitus,

Figure 5: Bubba's self-modified food bowl

crackling or popping sounds in the elbows bilaterally. When fully anesthetized, the left elbow moved well, although it was more resistant to flexing and extension than in the right limb. We were unsuccessful in obtaining a quality sample from arthrocentesis. A sample of synovial fluid was submitted for culture but the sample was blood contaminated. The results showed no growth of organisms. Radiographs showed that the degeneration had not progressed significantly since the last radiographs.

Bubba was showing signs of improvement and veterinary staff decided to give him time off of the cart. On 15 Mar 2011 (day 44 of treatment) Bubba spent 1 ½ hours off of the cart and was able to move the left front limb and bear some weight on it. He was still not able to bear full weight on the limb without collapsing. Since his appetite was normal and he was eating reliably, the injectable Meloxicam was switched to oral Meloxicam every other day. After having some time off of the cart Bubba was left on the cart for the next week before we removed him from the cart again. On 24 March 2011 (day 52 of treatment) he was left off of the cart for the full day. He was observed moving around the room and using the left front limb. He was still generally weak in all limbs from

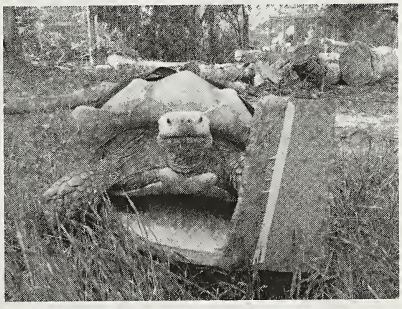

Figure 6: Bubba outside

spending nearly the last three months on the cart. Four days later, he again had time off of the cart. On March 29th and 30th, 2011, the weather was finally warm enough for Bubba to spend several hours outside (fig 6).

By this time in his treatment, Bubba had become quite the fighter when it came to adjusting his cart in any way. The straps would often come loose and Bubba would shift himself on the cart. On 4 April 2011 (day 64 of treatment) while spending some time outside, Bubba managed to loosen the straps enough to get off of the cart. He spent four hours outside with about two hours off of the cart and he fought being placed back on the cart. During this time he was seen using the left front limb quite well and was able to support his weight. We did note that he did not hold the left front limb as vertical as the right front limb. We left him off of the cart overnight. The next morning he was observed getting around the room with little or no trouble. He was left off of the cart and his mobility was monitored. The injectable Ceftazidime was discontinued.

After three days of being off the cart and ambulating around his room, we decided to return Bubba to his exhibit the afternoon of 7 April 2011 (day 67 of treatment). He had no change in his gait after being off of the cart and was still able to fully support his weight. On 8 April 2011 he was ambulating normally around the exhibit in the afternoon. It was noted by keepers that he was slower moving around in the morning. His prescription for Meloxicam every other day was extended for three additional weeks. A recheck on 19 May 2011 (day 109 of treatment) showed Bubba walking normally and bearing weight well on his left front limb. He was also observed to be moving quicker than he had been. His Meloxicam was reduced to Mondays and Thursdays. Bubba was rechecked three weeks later and was observed to have a normal gait and the oral Meloxicam was stopped. He continued to do well on exhibit. The Reptile Keepers were advised to monitor for any signs of lameness.

Bubba had his annual physical examination on 6 October 2011 (253 days post presentation). Blood was drawn for CBC, Blood chemistry panel and radiographs of both front limbs were taken. Radiographs showed that the left front limb still contained a large lytic lesion that encompassed the left distal humeral condyle with both proximal radius and ulnar head involvement. Compared to the previous radiographs taken 4 February 2011, the lytic lesion appears to be subjectively larger within the humeral condyle with additional bone loss. Bubba has been asymptomatic for left front limb lameness since being returned to his exhibit and taken off all medications. However, radiographic signs persist and are worse than in previous examinations. Differentials for the lesions include infection, (bacterial or fungal), or neoplasia, such as synovial cell carcinoma or osteosarcoma. Since Bubba has been asymptomatic it is suggested that he have an examination every six months with radiographs to track any changes in the left front limb. Additional diagnostics may be pursued at the next exam if there is any progression in the lesions.

Outcome

Through the use of rest and restricted movement using a modified cart, analgesics and antibiotics, Bubba recovered and was allowed to move back into his exhibit. The staff knows that Bubba's medical problem is not completely resolved and will require monitoring through bi-yearly radiographs. His cart remains at the Veterinary Hospital in case it is needed in the future.

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Primary Reptile Keeper: Bill Tabb

Maintenance Staff: Kris Lanzarotta and Ron Languasco

Radiologists at UC Davis VMTH: Dr. Allison Zwingenberger

Curator: Harrison Edell

Animal Care Supervisor: Susan Healy

Photographs by Alison Mott, Kate Gore and Sacramento Zoo Photography Staff

Lonesome George: Conservation Icon

Lonesome George, the world's last known Pinta Island tortoise (*Chelonoidis nigra abingdoni* a.k.a. *Geochelone elephantopus abingdoni*), at the Charles Darwin Research Station in the Galápagos Islands. *Photo: ©Shutterstock*

Any journal issue dedicated to Chelonians would not be complete without mentioning Lonesome George, the world's last known Pinta Island tortoise, a subspecies of the Galápagos tortoise. He has been labeled the rarest creature in the world, and is a famous conservation icon. Estimated to be 100 years of age, there have been numerous unsuccessful attempts to find other Pinta Island tortoises and to breed Lonesome George with similar subspecies of Galápagos tortoise. If these attempts remain unsuccessful, the Pinta Island tortoise will become completely extinct upon Lonesome George's death. With half of the world's 300 species of turtles threatened with extinction, the tale of Lonesome George is a call to action for those who care about the world's endangered Chelonians. *Source: wikipedia.org*

Hatching Success of the Madagascar Flat-tailed Tortoise *(Pyxis planicauda)* at the Fort Worth Zoo

By Nathan Haislip, M.S., Terrestrial Ectotherm Keeper
Fort Worth Zoo, Fort Worth, TX

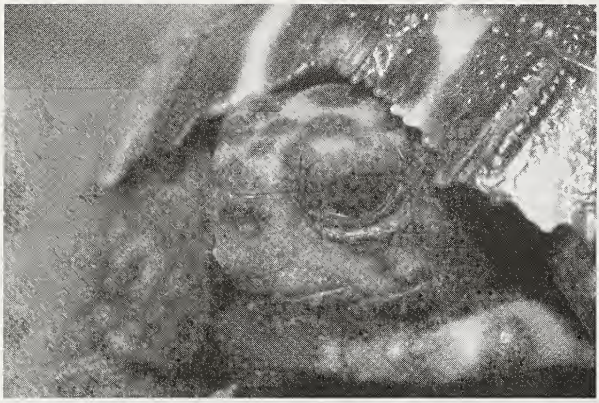
Hatchling flat-tailed tortoise (*Pyxis planicauda*) at the Fort Worth Zoo. *Photo by Nathan Haislip*

Introduction

The Madagascar flat-tailed tortoise (*Pyxis planicauda*) is a critically endangered tortoise species restricted to a small portion of the western coast of Madagascar. This species has an incredibly restricted range with the majority of the population only occupying a range of approximately 500 km^2 (Pedrono, 2008). Officially listed as endangered in 1996, it was predicted that the species might be extinct as early as 2030, however conservation efforts have made this prediction obsolete (Leuteritz, 2008). Although populations are secure in captivity, threats such as over-collection and habitat destruction still endanger the safety of this species in the wild. This species is also often collected and eaten by the endemic people. Population size is estimated at less than 30,000 left in the wild (Young, 2008), with fewer than 150 animals maintained in captivity. Several AZA institutions have sustained this species since the mid-1970s but the first successful hatching of a Madagascar flat-tailed tortoise occurred in 1995 (Goetz et al., 2002). Since then, only a handful of institutions have been successful in producing more captive offspring.

Physical description

Flat-tailed tortoises are a small tortoise species, only reaching a maximum carapace length of approximately 13-14 cm with females being on average larger than males (Pedrono, 2008). As hatchlings, they weigh only about 18g with a maximum weight of approximately 300-400g. They



Hatchling flat-tailed tortoise (*Pyxis planicauda*) at the Fort Worth Zoo. *Photo by Nathan Haislip*

have a yellow plastron and a yellowish to dark brown carapace. Males can be distinguished from females easily by the presence of a longer tail and a concave plastron. The posterior portion of the plastron is flexible to facilitate egg deposition. Clutch size is usually limited to one or possibly two eggs, however females can lay up to three clutches a year.

Husbandry Methods

The Fort Worth Zoo received four wild caught, adult *P. planicauda* (2.2) on breeding loan from the Baltimore Aquarium in 2004. Since acquisition, breeding attempts have been made with eggs laid multiple times; however the eggs were always infertile. After discussions with Michael Ogle (*P. planicauda* studbook coordinator) and Dan Pearson (very successful private keeper of *Pyxis spp.*), we decided to change the daily husbandry of these animals. Historically, the animals had been kept on a concrete substrate to facilitate cleaning with a large nest box provided. They were allowed outdoor access throughout the breeding and egg-laying season. The "rainy" season was simulated by placing a rain ring in the indoor enclosure and raining on the tortoises for a period of no more than 30 minutes.

The diet consisted of a variety of greens, apples, sweet potato, carrots, alfalfa sprouts, tomatoes, and mushrooms, all finely diced together, and rabbit chow sprinkled on top for added supplementation.

Indoor run of adult flat-tailed tortoises *(Pyxis planicauda)* at the Fort Worth Zoo. A large hide box is also included in each run. *Photo by Nathan Haislip*

The changes to the diet included the addition of more mushrooms, as well as a variety of browse items offered during the spring and summer. These items included mulberry, hibiscus flowers, and *Opuntia* fruit; all of which were relished by the tortoises.

The exhibit was also greatly modified by converting the exhibit from a concrete substrate with nesting boxes to the entire exhibit acting as one large nesting box for the females. However, several substrate layers were incorporated. We started by laying down a layer of lava rock to act as a drainage layer. This was then covered by weed barrier and the nesting substrate then added to prevent the substrate from settling into the lava rock or washing out of the exhibit. The substrate mixture was equal parts of peat moss and play sand.

The tortoises were still given outdoor access daily throughout the breeding and egg-laying seasons. One of the largest changes however, was the installation of the misting systems in both the indoor and outdoor portions of the runs. We noticed that the rain ring did not allow for adequate saturation of the entire exhibit and in talking with other successful *Pyxis* breeders, we decided to change to a misting system. Misting was initiated at least three times a week for approximately one to three hours during the spring and summer months. Throughout the breeding season, misting was increased to every day, which seemed to encourage copulation greatly as the tortoises were often witnessed copulating during and soon after the misting cycle. Males were also allowed to spar during the onset of breeding season. It is unknown whether sparring in this species aids in spermatogenesis, however this may have encouraged spermatogenesis or copulation efforts.

Egg Cycle

The successful egg was found on September 4, 2011, and immediately cooled at a temperature of 66°F on a substrate of vermiculite (1.5:1 vermiculite to water). This species requires a winter dormancy before the egg will begin to develop. After the three-month cooling cycle, we warmed the egg to 82°F until hatching. Development was seen within one month via candling. The individual hatched approximately four months after the incubation cycle began on March 12, 2012. The juvenile is currently being held in our nursery at a temperature of approximately 76°F, misted daily and fed daily a diet similar to the adults. This individual is the first offspring of a wild-caught pair in several years and reinforces the importance of captive rearing.

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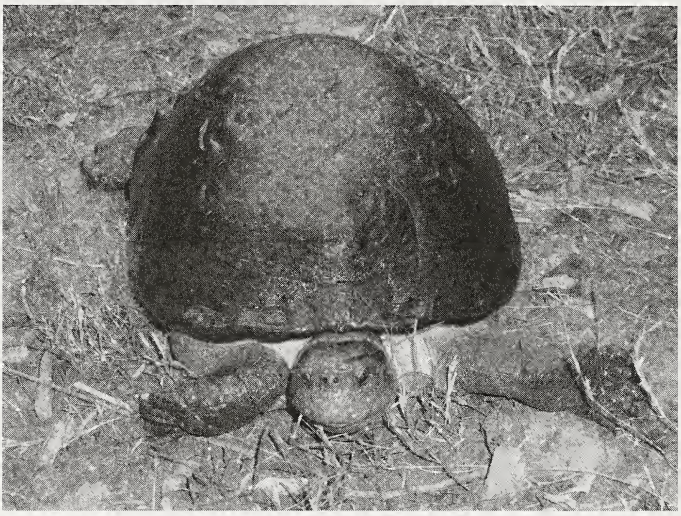
The Evolution of Wrangling Turtles in Houston, Texas

By Tammy Buhrmester, Primate Keeper and
Cynthia Leeson, Senior Primate Keeper, Houston Zoo, Houston, TX



Ms. Swirly Shell. *Photo by Tammy Buhrmester*

Introduction

The Houston Zoo is a 55-acre zoological facility in Houston, TX that houses 4,500 animals representing 800 species. Among the zoo's many species of reptiles, four endangered species of turtles are housed in the Wortham World of Primates orangutan exhibit: yellow-headed temple turtles (*Heosemys annandalii*), Malaysian painted river terrapins (*Batagur borneoensis*), Malaysian giant river turtles (*Orlitia borneensis*) and Fly River turtles (*Carettochelys insculpta*). In late 2003, the Houston Zoo was the first to hatch yellow-headed temple turtles in a zoological setting in the United States.

Biology/Habits

The yellow-headed temple turtle is a large turtle native to Southeast Asia. Their name derives from the fact that this turtle is often found near Buddhist temples. The turtles are aquatic and can grow to over 60 cm (20 inches) in size and live in captivity for up to 35 years. Male yellow-headed temple turtles can be distinguished from the females by their thicker tail and concave plastron. They are herbivores and feed on vegetation and fruit growing in and around its aquatic habitat. Breeding season is between December and January. The usual clutch size is four elongated, hard-shelled eggs.

The Malaysian painted river terrapin is one of the most endangered river turtles in Southeast Asia. The terrapins are aquatic and show marked sexual dimorphism. The female is larger than the male and can grow to 60 cm (20 inches) in size and get up to 25 kg (55 lbs.). The males are smaller and grow to 30-40 cm (11 inches). The male's head will turn white and a bright red stripe will appear between the eyes during breeding season.

The Malaysian giant turtle is the largest freshwater turtle in Southeast Asia. Its meat is highly sought after for food, resulting in a rapidly diminishing population. They can grow to 80 cm (30 inches)

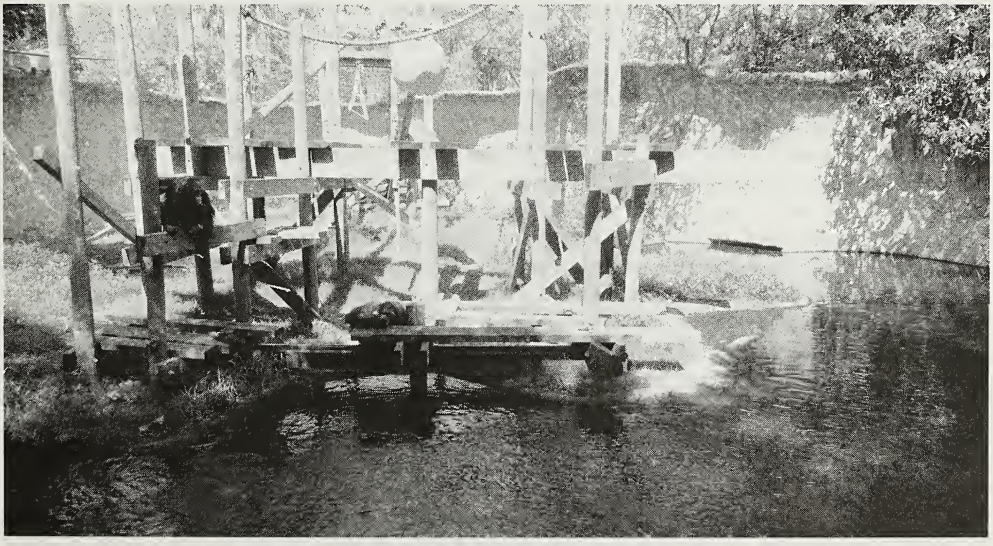
in size and weigh up to 50 kg (110 lbs.). The adult male has a longer, thicker tail than the female. The female Malaysian giant turtle lays enormous eggs along riverbanks, which are oval-shaped with brittle shells.

The Fly River turtle, also known at the pig-nosed turtle, is a freshwater turtle found in Australia and New Guinea. It is one of the best adapted species of turtles to an aquatic lifestyle. The pig-nosed turtle is almost entirely aquatic, with only the female leaving the water to nest. The nose looks like that of a pig, having nostrils at the end of a fleshy snout. Males have a longer and narrower tail compared to the females. They can grow to about 70 cm (28 inches) and weigh 30 kg (65 lbs.). This species of turtle is omnivorous, eating a wide variety of plant and animal matter. Females reach maturity after 18 and males at 16 years of age. They lay their eggs in the dry season. When the offspring are fully developed, they will stay inside the eggs in hibernation until conditions are suitable.

The Beginning

On 11 December 2001, Hong Kong authorities seized a shipment of 7500 Asian turtles that were headed to markets throughout China. The shipment contained 12 species of chelonians, many of which were classified as threatened or endangered. Hong Kong authorities notified and turned over the confiscated animals to the Turtle Survival Alliance (TSA). Initially they were housed at Kadoorie Farms and Botanical Gardens, Hong Kong, a rescue center and a TSA partner. Rather than destroy them, many of the animals were shipped to the USA to establish "assurance colonies". On 27 December 2001, the first shipment of 300 turtles arrived in the United States. By 12 January 2002, four shipments totaling 3200 animals had been received in Miami, FL and had been moved to Al Weinberg's Allapattah Flats Turtle Reserve in Port St. Lucie, Florida, which served as the staging area for evaluation and treatment. Such a massive rescue effort would not have been possible without this facility. Dr. Joseph Flanagan, Houston Zoo Head Veterinarian, assisted teams of veterinarians and turtle care-givers from around the USA in this undertaking. The project was a great cooperative effort for all to share their expertise and the knowledge of turtle care in the aid of so many sick and injured turtles. Turtles were shipped as soon as possible to several facilities, public and private, around the country for ongoing care and breeding.

The Houston Zoo's orangutan exhibit is a mixed-species facility. The main focus of the exhibit is the orangutans, but the moat is used to house several species of animals, such as fish, ducks and turtles. The



Houston Zoo orangutan moat. *Photo by Tammy Buhrmester*

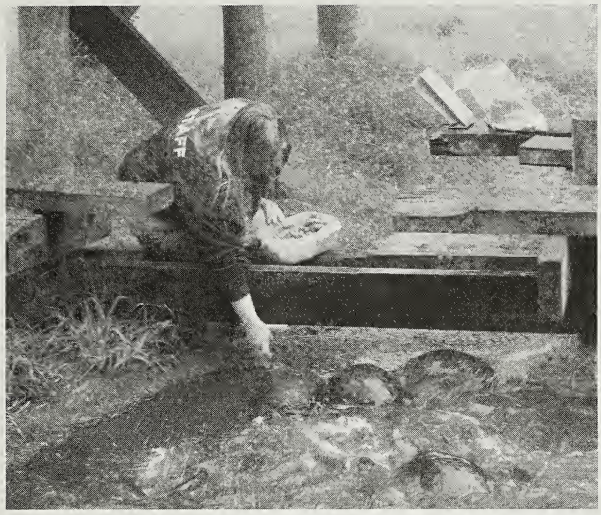
moat is crescent shaped and approximately 3-4 meters deep, 3-5 meters wide, and 10 meters in length. There is a wooden platform structure at the front of the exhibit which is used by the orangutans for locomotion and enrichment at the water's edge.

In May 2002, four Giant Malaysian river turtles were released into the orangutan exhibit's moat. They had been part of the large confiscation in December 2001 cared for by the TSA. The moat already housed red eared sliders (*Trachemys scripta elegans*), koi (*Cyprio carpinus*) and two wood ducks (*Aix sponsa*). From May to September, keepers fed the released turtles, but none were observed eating. In early September 2002, three turtles were observed surfacing to feed. The moat did not have a heater to maintain the water at the correct temperature (above 20 C); therefore the turtles needed to be caught up and transferred to the Herpetology building during the winter months. In October 2002, while keepers fed them in the afternoon, they would attempt to catch them up with a long-handled fish net to transfer them to their winter holding area. The keepers were able to catch a few at a time using this technique.

Ms. Knot Head. *Photo by Tammy Buhrmester*

In late December 2003, one female yellow-headed temple turtle was captured by net and was taken to the veterinary hospital for examination. She was found to be gravid with four eggs and was transferred to a holding facility in the Herpetology building. All females have been captured and examined each breeding season since that time. Once they arrive at the herpetology building, they are closely monitored. The gravid turtles are housed at the holding facility in medium water land tubs that is 76"Lx35"Wx24"H. The tub is three-fourths water and one-fourth land. The land section is filled with a 50/50 mixture of play sand (the kind you find in a child's sandbox) and top soil. A 150-watt UVB heat bulb is placed over the land "nesting area". They are normally housed individually, but on occasions they have been housed in pairs. During their monitoring, the turtles are examined to determine the progress of the eggs. On occasion, Oxytocin may be used to aid the turtles in laying the eggs. It is given to them when veterinarians are sure the eggs are mature in the uterus. If not fully calcified, staff waits until the turtle starts to dig a nest and check that the eggs are ready. Eggs have been laid in water and on land, both buried and left on top of the dirt. Once the eggs are laid, they are weighed and measured, both length and width. After they are examined, they are placed in moist vermiculite and placed in the incubator. The incubator is set at 82F with 60-70% humidity and the eggs typically hatch in approximately 90 days. We have had them hatch as early as 70 days and as late as 150 days. The female yellow-headed temple turtle that was captured in 2003 laid four eggs. Two of the eggs were not viable and two hatched. This was the first successful hatching of a yellow-headed temple turtle in a zoo in the Unites States.

The turtles were moved into winter housing each year from 2002 to 2004. In late 2005, a heater was installed in the orangutan moat to keep the water at or above 21 C. This allowed the turtles to stay in the exhibit year-round. The turtles are still collected in early winter for general examinations and to check if any of the females are gravid. If they are gravid, the female turtles are transferred to the Herpetology Department until their eggs are laid; after which, they are returned to the orangutan



Senior Keeper Cynthia Leeson feeding yellow-headed temple turtles. *Photo by Tammy Buhrmester*

moat. The turtles are caught by hand rather than with a net, since it was generally more successful at catching the target individual(s) while having minimal behavioral impact on the other animals in the moat (other turtle species, koi, ducks, etc.). When the net was used, the turtles became wary of the keeper and were less likely to come within reach for capture for several days afterwards.

The Training Begins

The orangutan keepers noticed that turtles were coming out of the water and walking around on the exhibit to consume the primate browse biscuits fed as part of the daily orangutan diet. In early 2005, after discussion between animal care staff and the veterinarian, Senior Keeper Cynthia Leeson started offering browse biscuits to the turtles at the water's edge to encourage them to come out of the moat to eat. The keepers would sit on the wooden platform at the water's edge and offer gently-soaked browse biscuits every morning. Within a short amount of time, turtles started lining up for food. They would climb over the fish and each other to get to the keeper and their morning hand-fed biscuits. By 13 May 2005, she was able to have them come up close enough to be able to pick them up for examination. At this time, three turtles were caught, one of which was gravid and taken to the Herpetology Department, where she laid four eggs.

From 2005 until late September 2008, the Houston Zoo received several more Malaysian giant turtles, yellow-headed temple turtles, Malaysian painted turtles and Fly River turtles, bringing the total number of endangered turtles living in the orangutan moat to twenty-six. The keepers consistently feed the turtles soaked biscuits every morning by hand, with an understanding that this is the only way the turtles would get their morning diet. This method of feeding encourages the turtles to come up to the water's edge to receive their food and it allows keepers the ability to get a good look at them. The turtles' main diet consists of turtle pellets four days a week and assorted lettuces and fruit three days a week. Biscuits are offered in the morning only. Newly acquired turtles slowly started to appear with the rest of the turtles at the water's edge once they became accustomed to the routine. Through this method of feeding the turtles, the keepers have been able to catch most of the turtles by hand consistently since 2008.

In 2010, a chart was made noting the individual characteristics of each turtle, allowing the keepers to identify individual turtles. Use of these charts aids in teaching other keepers in the department how to identify individual turtles on sight. The charts also allows the keepers to know which turtle needs to be caught at what time of the year, monitor growth, body condition, and overall appearance. From these examinations and captures we have successfully been able to hatch eleven turtles so far.

The Future

The keepers plan to continue the training of the turtles. New staff is trained to join in to catching up the turtles for their yearly examination. The Fly River turtles are now consistently coming up for feeding in the morning. The goal is to catch them all up this year for examinations. Since they are the quickest and have a very slick surface, it will be a test for the keepers to catch them with efficiency.

We would like to encourage all zoo staff and guests to get to know these wonderful creatures and how interesting and fun they can be to feed and take care of.

At the end we have to thank all of our wonderful charges that we are so happy to take care of on a daily basis. So we say thank you to Knot Head, Swirly Shell, Perfect, Lefty, Righty, Feisty, Martini, Rossi, Mellow Yellow, Squirrelly Dervish, Spot, Boo, Divet, Blackjack, Watermelon, Perfect and the others that we have not yet gotten to know well enough to name yet. It has been a pleasure to work with these wonderful creatures everyday. We would like to thank Dr. Joe Flanagan for forging us in the direction of caring for and appreciating these turtles. We would like to thank the entire Herpetology Department staff and supervisors for taking in and taking care of our wonderful turtles during their gravid period. We would also like to thank the entire Primate Department staff and supervisors for their support during all of our turtle adventures.

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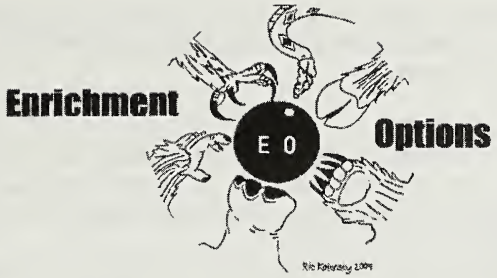
TOGO - CIRCA 1996: A stamp printed in Togo shows the tortoise known as Angonoka, Ploughshare, or Madagascar Tortoise, (*Geochelone yniphora*, formerly *Astrochelys yniphora*), circa 1996. Illustration by Jim Pruitt / Shutterstock.com (bottom stamp: IgorGolovniov / Shutterstock.com). International Zoo News (Vol. 59/2, No. 393, March/April 2012) recently reported that Durrell Wildlife Conservation Trust reintroduced 20 captive-bred ploughshare tortoises, the world's most threatened species of tortoise, in a national park of Madagascar in November of 2011.



Coming Out Of Their Shells: Enrichment For Tortoises

By
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Introduction

Traditional enrichment for reptiles has typically focused on enhancing environmental features of enclosures (e.g., plant variety, ground substrates, etc.), animal health (i.e., misting and soaking animals), and nutrition (i.e., provision of insects, variety in the diet). These types of enrichments are important practices that can enhance an animal's environment and well-being. However, novelty in the form of foods, objects and scents may be equally stimulating and important for reptiles, as has been shown for mammals (Shepherdson, 2010) and birds (Elston and Plasse, 2008).

Studies regarding enrichments for chelonians are limited in the literature, though some published evidence exists regarding the benefits of enrichment for turtles. Sea turtles increased investigative and grooming behaviors and reduced pattern swimming when enrichment devices were provided (Therrien et al., 2007). A Nile soft-shelled turtle (*Trionyx triunguis*) sought out stimulation from objects and displayed "play" behavior previously only described for mammals and birds (Burghardt et al., 1996).

The objectives of this study were to introduce captive-housed tortoises to novel enrichments to determine the extent of their interaction with new and different items and to compare interactions among food, object and scent enrichment. Additional goals were to compare tortoise behavior under routine management vs. novel enrichment presentation and also to determine the amount of contact between tortoises that were housed in pairs (a form of social enrichment).

Animals, Housing and Methods

This study took place from December 2011 through January 2012. Three Burmese star tortoises (*Geochelone platynota*; two males, one female) and five Forsten's tortoises (*Indotestudo forstenii*; three males, two females) were observed, for a total of eight tortoises. Four tortoises were kept as male-female pairs, and four were kept separately. The tortoises were housed in an off-exhibit greenhouse under both natural and artificial light, in either a run with cement and plywood sides (approximately 90 X 38 X 20 in., 1 pair and 1 single; or approximately 35 X 38 X 20 in., 1 pair) or a rubber tub (approximately 49 X 33 X 21 in., 3 single). Cypress mulch was used as ground substrate and each enclosure contained a water bowl, food pan, heat source, and a shelter for privacy. Tortoises were fed once daily in the morning a diet of mixed greens and vegetables with commercial biscuits (Mazuri® Tortoise Diet and Marion Leaf Eater® Food), and had access to their food throughout the day. A HOBO® data logger (Onset Computer Corporation) was used to record temperature inside the greenhouse.

Table 1. Ethogram used during tortoise enrichment study at the Fort Worth Zoo. Several behaviors were documented to create a complete time budget, however only the categories discussed in this paper are described.

Behavior	Definition
Enrichment Interaction	Touching, viewing, and /or approaching novel items; if no physical contact is made (i.e., viewing, approaching), head must be oriented toward the enrichment and behavior must occur within one tortoise length from enrichment
Moving	Locomotion including walking, wading and climbing
Stationary	Body in fixed position
Not Visible	Behavior not observed because tortoise within its shelter

Location	Definition
Contact	Physically touching another tortoise
Under Shelter	Within provided cover; at least 50% or more of body

During each daily observation session, the behavior (Table 1) of each tortoise was recorded every minute for 40 minutes (Scan Sampling; Martin and Bateson, 2007). Data collection took place between 1300 and 1600 hours. Behavior was observed over six days under routine husbandry without novel enrichment to generate a baseline time budget before new enrichments were presented. Following the baseline treatment, a randomly chosen enrichment item was presented during the observation session. Six items that the tortoises did not have previous exposure to were used, representing three categories: food, object and scent. The foods were edible flowers (four total, ranging in size from 1 to 2 in.) and a fresh strawberry. The objects were a ping pong ball and a wicker ball. Because the tortoises had not been previously exposed to a ball, a ping pong ball and 2 in. wicker ball were chosen because their small size was expected to be less intimidating, and the tortoises were not large enough to accidentally swallow either type of ball. The scents were a fresh herb (basil; one sprig, approximately 6 in. long and containing stem and leaves) or a spice (nutmeg; 3 shakes on a piece of cypress mulch). One type of enrichment was presented per day and each enrichment item was presented twice, for a total of 12 days. The enrichments were placed in the enclosures in locations where the tortoises could see them, typically within the center of the enclosure. Each tortoise was offered the same amount of enrichment, whether housed singularly or in pairs. After the enrichment treatment, behavioral data were collected for an additional six days in order to determine any changes in baseline behavior.

Results

During the enrichment treatment, tortoises spent an average of 13% of time interacting with the novel enrichments (Fig. 1). Tortoises expressed natural behaviors toward the enrichments, including investigation and/or touching, and consumption of the edibles (Fig. 2). Tortoises spent less time stationary during the enrichment treatment than before or after, and spent less time moving in general after the enrichment treatment (Fig. 1). They also spent less time in their shelters when enrichments were present (38% of time during the enrichment treatment vs. 48% before and 58% after). Tortoises spent the most time interacting with food enrichment (19% of time vs. 10% of time for objects and scents), primarily because of the strawberry. The strawberry received the most interaction; the nutmeg received the least (Fig. 3).

The tortoises housed in male-female pairs spent an average of 49% of time in contact with one another over the course of the three treatments (56%, 31%, and 59% of time, respectively). Temperature in the greenhouse was consistent throughout the treatments; average temperature was 72° F, reaching an average of 89° F during the day and 62° F at night.

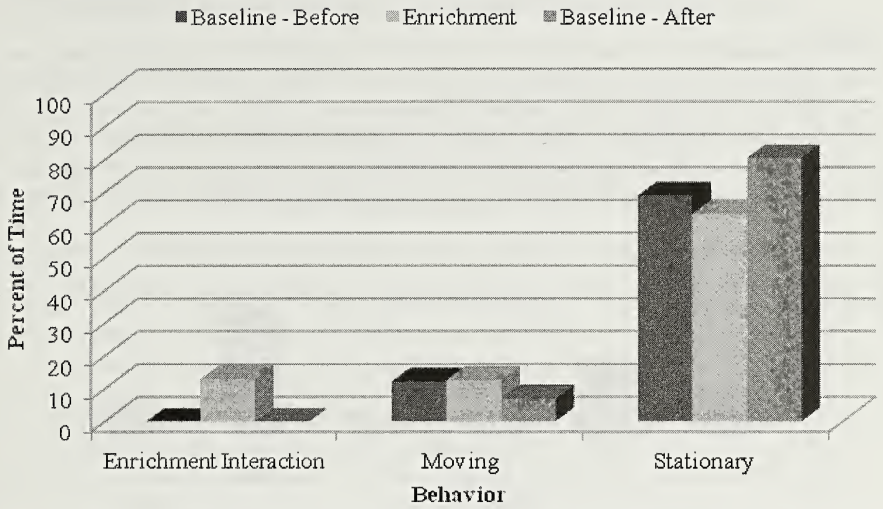

Fig. 1. Tortoise (*Geochelone platynota* and *Indotestudo forstenii; n=8*) behavior during an enrichment study at the Fort Worth Zoo.

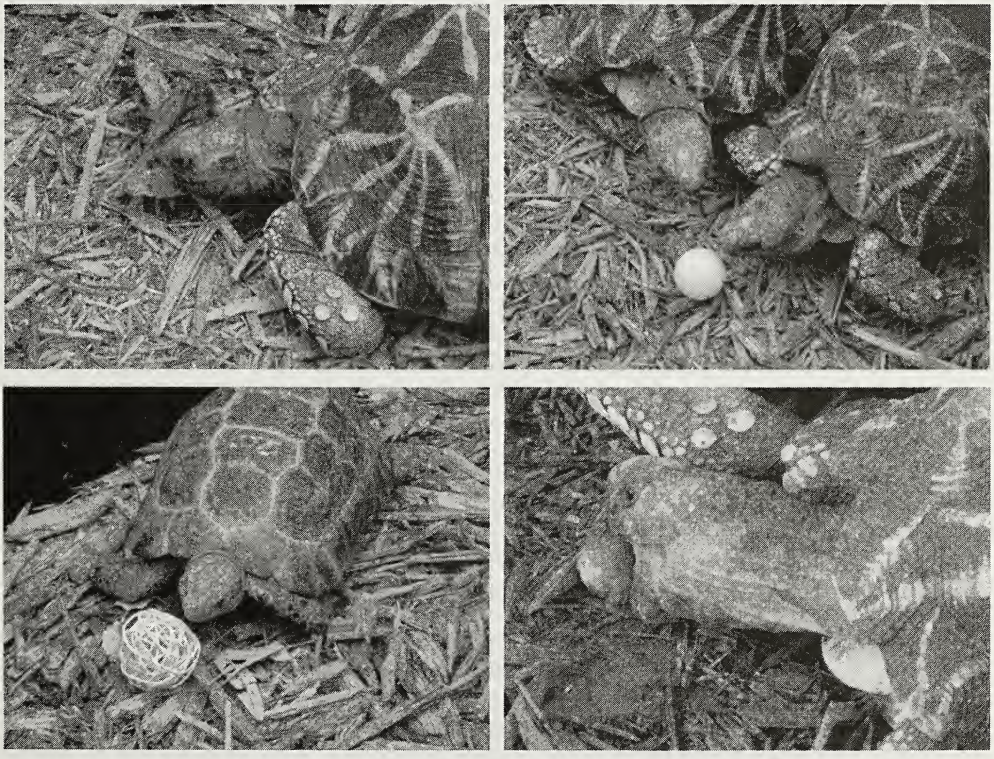

Fig. 2. Tortoises interacting with enrichments during a study at the Fort Worth Zoo. Clockwise from top left: *Geochelone platynota* consuming an herb, *Geochelone platynota* investigating a ping pong ball, *Geochelone platynota* consuming a strawberry, and *Indotestudo forstenii* investigating a wicker ball. (Photos: J. Elston)

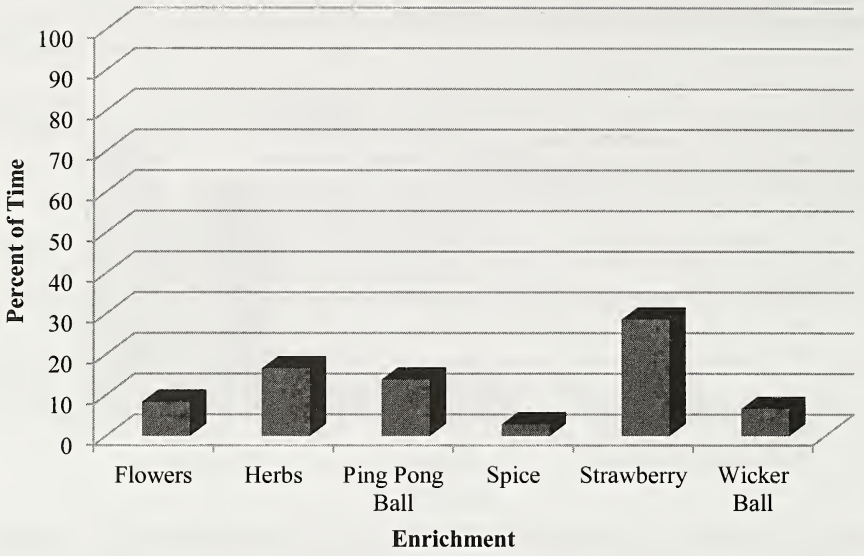

Fig. 3. Tortoise (*Geochelone platynota* and *Indotestudo forstenii; n=8*) interaction with enrichments during a study at the Fort Worth Zoo.

Discussion

The tortoises spent the most time interacting with food enrichment, which was not surprising because food enrichments are often favored by animals in general (Young, 2003). In a comparison of enrichments for an African serval (*Leptailurus serval*), the serval interacted more with edible enrichments than inedible enrichments, though both types did receive attention (Kunkel, 2011). The tortoises spent a shorter amount of time interacting with the flowers primarily because of their small size, which made them easy to grasp and swallow. Because some favored foods can be consumed fairly quickly by tortoises, if a goal for the enrichment is to increase time spent foraging (a natural behavior for tortoises), combining foods with objects that require manipulation to consume the food will lengthen interaction time.

The ping pong ball generated more interest than the wicker ball, possibly because its white color and smooth, round shape made it resemble a food item. The tortoises that did interact with the ping pong ball spent most of their time biting at it. Size of ball would need to be taken into consideration for larger tortoises to prevent any possible consumption.

Very little interaction occurred with the nutmeg; however, a great deal of time was spent with the fresh herb (basil). In fact, the herb received the second highest amount of interaction after the strawberry. Even though the herb was categorized as scent enrichment during this study, it became a combination of scent and food enrichment because it was consumed. The palatability of the herb and its composition (leaves and stem, which required much biting and tearing to consume it) likely contributed to the lengthy interaction. These attributes make fresh herbs an effective form of enrichment if goals are to increase foraging time and offer a novel gustatory and olfactory experience.

Once the enrichment treatment was underway the tortoises appeared to anticipate and expect to receive the enrichments. For example, several tortoises began watching, moving toward and following the observer. These behaviors began during the enrichment treatment and continued during the first part

of the following baseline treatment, after which the tortoises became more stationary.

Tortoises spent less time in their shelters in the presence of enrichment, which illustrates the benefits of enrichment for zoo visitors as well. If animals are stimulated to explore and interact with their environment they are more likely to be viewed by visitors, which may lead to greater learning, understanding and appreciation by the public. For example, a novel enrichment initiative in the form of a water sprayer incited natural, active behaviors in hippopotamuses (*Hippopotamus amphibius*) which made them more visible to visitors and in turn generated positive responses (Elston, 2010).

The findings in this paper were discussed in terms of group averages; however, there are often differences in reactions and preferences among individual animals toward different enrichments (Heinz et al., 1998). For example, during the baseline treatment before enrichments were presented in this study, a Forsten's female remained hidden within her shelter and not visible 100% of time. After the enrichment treatment began she reduced her time within her shelter to 73% of time and was often observed at the entrance of the shelter looking out (not visible only 43% of time). When enrichment was present she explored her surroundings, engaged in appropriate contact with enrichments and reduced her time spent hidden in her shelter, indicating that the presence of enrichments impacted her in a positive way. During the baseline treatment after enrichments were presented she returned to her shelter for 85% of time. Another tortoise showed great interest in the enrichments, and 75% of the time enrichments were offered she was interacting with them within the first minute of presentation.

Tortoises that were housed in pairs spent around half of the time in contact with their companion. Even though each tortoise had plenty of space to move away from their companion if they chose to, they opted to remain in close vicinity. This indicates that social interaction between male and female tortoises is likely desirable. Further study on social interaction between same-sex tortoises is necessary to determine the overall value of companionship for captive-housed tortoises.

Conclusion

During this study novel items were presented separately to learn the effects of different types of enrichment. However, it would likely be beneficial to tortoises to offer a combination of enrichments, which is a common and effective practice for enrichment presentation (Young, 2003). While the value of novel foods and objects for tortoises has been demonstrated by this study, additional work is necessary to determine beneficial types of novel scent enrichment. Because tortoises have a keen olfactory sense (Obst, 1988; Ebenhack, 2012), it is possible that nutmeg was simply not potent or favorable enough to stimulate curiosity in these tortoises.

Overall, the enrichments generated interest among the tortoises, prompted interaction, and encouraged exploration of their environments. If these types of behaviors are goals for enhancing tortoise management and well-being, then offering novel foods, objects and scents can help accomplish these goals. In addition, during this study the tortoises regularly used their shelters and those housed with companions spent much of their time in contact with one another. This indicates that in addition to novelty, social companionship and access to a form of cover for privacy are important components for enriching the captive tortoise environment.

Acknowledgments

Thanks to the staff of the Fort Worth Zoo Animal OutReach and Conservation Center (ARCC) for excellent care of the tortoises and to Remekca Owens, Public Relations Manager, for review of this paper.

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Huge thanks to Jennifer for her great enrichment contribution to this special chelonian issue of the AAZK *Forum*! This well-formulated study comparing food, object and olfactory enrichment initiatives with two different species of tortoises reveals some interesting observations. Two of my favorite traits of this paper include:

The quality and diversity of literature cited which reveals the efforts into researching and planning this study. These references are great sources of additional relevant information.

The additional questions the research leads us to ponder: did the ping pong ball generate more interesting than the wicker ball due to its texture or color (maybe test other colors, textures?), when using herbs as enrichment how does the palatability and composition influence the amount of interest and the type of interest, such as olfactory, dietary, visual interest (possibly test the same herb but vary these components?) - *EO Column Coordinators*

"The outcome of any serious research can only be to make two questions grow where only one grew before." ---Thorstein Veblen

Disney's Animal Kingdom's® Turtle Cognition Program

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At Disney's Animal Kingdom® and The Seas with Nemo & Friends at Epcot® collaboration between members of the science and animal husbandry teams has resulted in creative projects to evaluate the cognitive abilities of a variety animals. It may not be surprising that cognitive research is conducted with bottlenose dolphins and mandrill monkeys, but here we describe the development and implementation of our successful program examining the minds of turtles.

In early 2009, Disney's Animal Kingdom's® Science Team and Bird, Herps and Inverts Husbandry Team began to work together on a proposal to develop a cognitive research program with the goal of highlighting the cognitive abilities of animals that park visitors might otherwise not think of as being highly intelligent. That is, visitors were often not surprised to discover that primates and cetaceans are capable of complex problem solving stating that they had seen similar work on television shows or other forms of media, but it was clear that they did not perceive herps to have the same cognitive capacities.

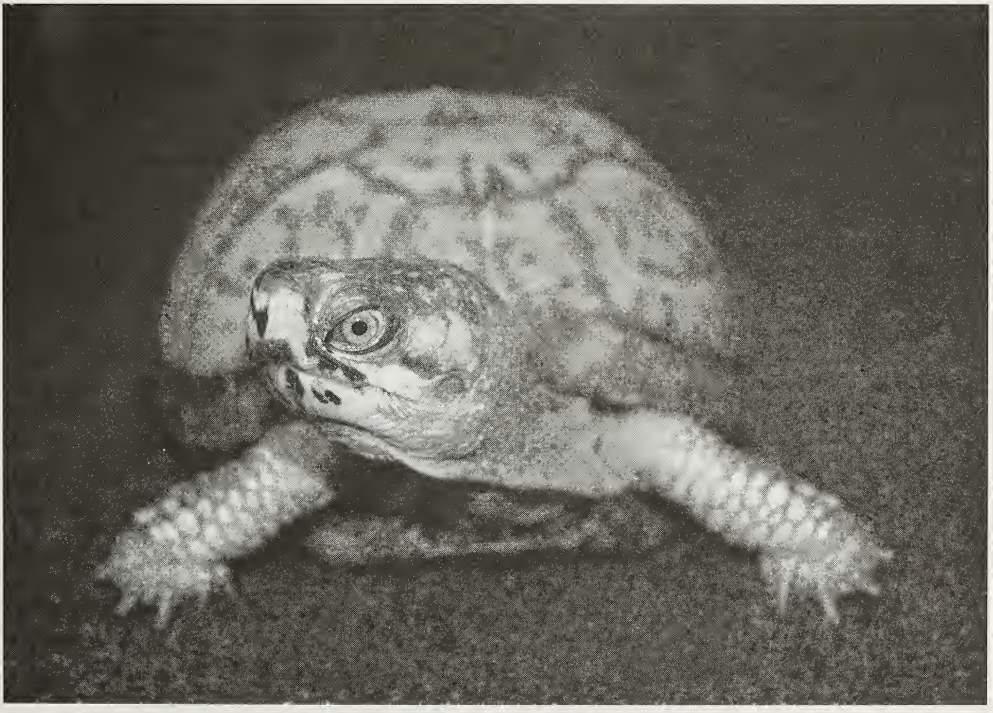

Figure 1. Eastern box turtle – "Flippy"

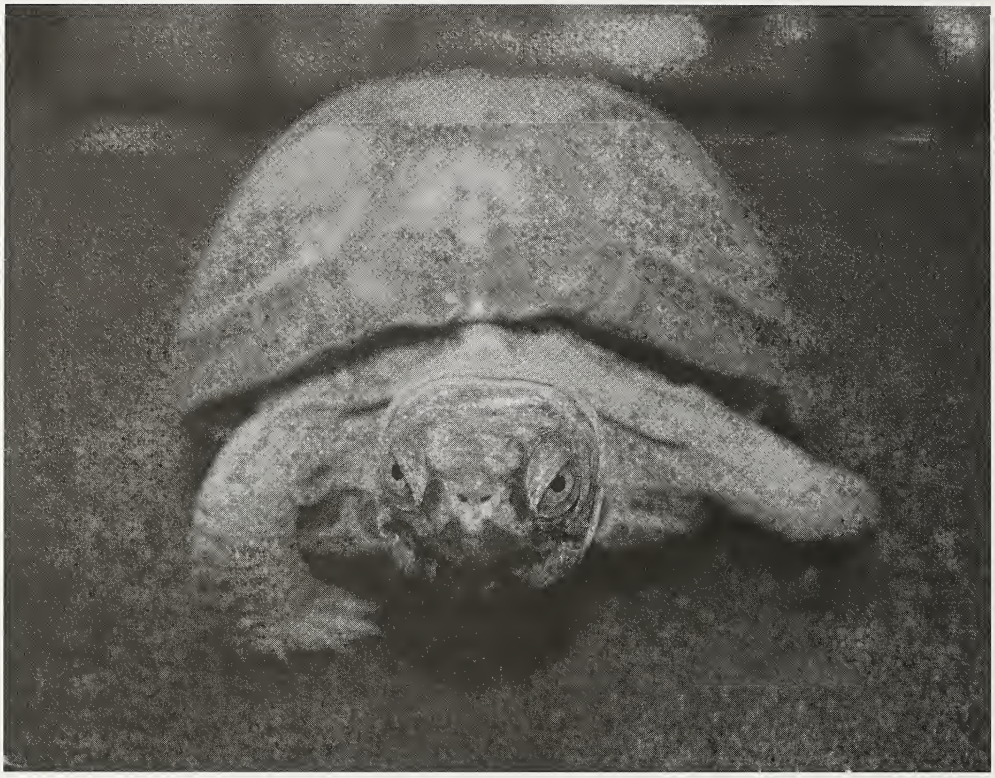

Figure 2. Eastern box turtle – "Mario"

Members of the teams first met to discuss potential animals to consider for participation in this new program. Several species were discussed and the following factors were used to select the particular species to focus on: being food motivated, being fairly habituated to human handling, having more than a single individual of that species, and species recommendations from animal keepers. Further, there was a strong desire to highlight the cognitive abilities of species that park guests would likely encounter in their own backyards or in the pet trade in order for this program to provide an additional opportunity to convey messages around choosing pets wisely and responsible pet ownership. For all of those reasons, the eastern box turtle (*Terrapene carolina*), was selected as the focus of this research program.

Disney's Animal Kingdom® is home to two adult male eastern box turtles; Flippy and Mario (see Figures 1 & 2). Both animals were hatched in captivity in 1998 and have lived at Disney's Animal Kingdom® since 1999. These turtles live separately, due to the highly territorial nature of adult male box turtles, and are rotated between an indoor terrarium exhibit and an outdoor area. The indoor exhibit is located in the reptile room at Conservation Station. This is a large room containing multiple reptile exhibits which can be observed by guests through large windowed viewing areas. This room is also equipped with a two-way microphone system which allows keepers to deliver presentations to guests about natural history and animal care and also allows guests to ask questions while the keepers carry out their daily routines. Given this interactive setup, the decision was made to conduct the cognitive research sessions in this space. Thus, this location allowed guests to view research sessions in progress, listen to keeper interpretation, and ask questions, but the glass windows provided some separation from the crowds to reduce distraction for the turtles while they work (see Figure 3).

The research staff and husbandry team worked together to devise the questions to be addressed

Figure 3. Reptile room in Conservation Station at Disney's Animal Kingdom®

by the cognitive research program as well as the specific design of the task to be conducted with the turtles. One keeper was appointed as the lead keeper on this project. This keeper assisted in all aspects of project development, piloting, scheduling, and serves as the primary contact between the research and husbandry teams. The lead researcher and this lead keeper worked together to conduct a thorough search of the existing literature and discussed tasks that best suited the natural history of box turtles. An overview of prior cognitive research with turtles and reptiles in general can be found in Burghardt (1977). From this review it became evident that turtles were a prime candidate for further cognitive research due to the fact that they are food motivated and are more easily trained with food rewards than other ectothermic reptiles. Further, they have a well-developed visual system and can discriminate shapes and colors (Burghardt, 1977). In order to utilize these aspects of box turtle natural history the decision was made that the first research questions to be addressed with this new program should be their ability to make simple and complex color discriminations. Thus, the research would test the ability of turtles to judge differences in shades along a variety of color scales. In order to avoid bias toward particular colors given their natural history (i.e. a potential preference for shades of green or red arising from their natural foraging behavior), it was decided that the first color discrimination studies would be between black and white and eventually shades of gray.

The first step in this process was to determine how to present the color choices to the turtles. Simple wooden paddles (painted cooking spatulas) were selected due to their physical similarity to other targets previously used with reptiles as well as being very affordable and easily painted. Next, the team had to establish the specific food rewards to use with the turtles. This was determined using simple food preference tests which involved repeatedly presenting each turtle with equivalent amounts of two food choices side by side and recording which one they selected most often. It quickly became clear that both turtles preferred meat food items over vegetable offerings. It was decided that the food

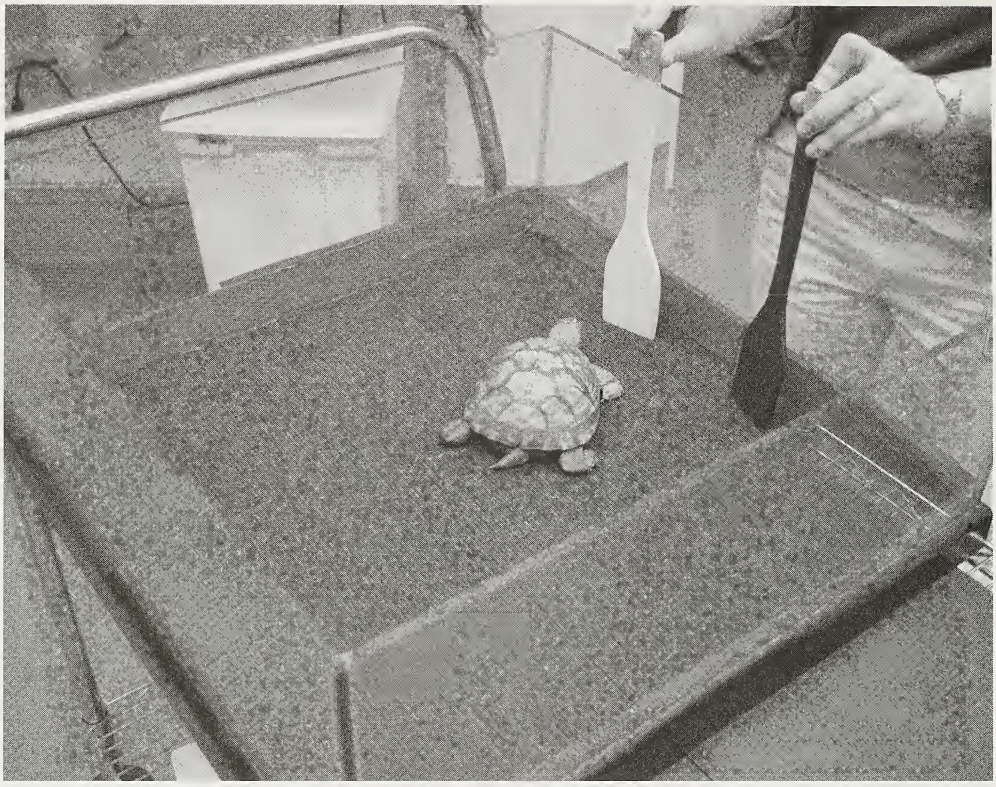

Figure 4. Box turtle cognitive research session

reward for these studies would be mealworm pupae. Both turtles worked for mealworms for several months, but then one turtle began refusing the mealworms and earthworm segments were substituted. In order to ensure that the turtles would be more likely to be food motivated, the meat rewards used as part of the study were taken from a portion of the turtles' overall diet. Thus, the turtles received the meat component of their diet during testing sessions while still receiving their standard salad diet three days per week.

To carry out the black/white discrimination test, the turtles first needed to be trained to approach a paddle of their assigned color. Mario was randomly assigned white and Flippy was assigned black as their correct color choices. The turtles were assigned different colors to ensure that responding was not due to some natural preference for darker or lighter objects but instead could be learned in either color direction. Using the meat food rewards, the turtles were then trained to approach the paddle of their assigned color. Each turtle was reliably approaching their paddle across the 60 x 60 cm Plexiglass™ arena lined with green outdoor carpeting within a single training session. Once the behavior of approaching their assigned paddle was well established (approximately five training sessions), the turtles were presented with both the black and white paddle on each trial and they needed to make a correct choice between the two colors to receive the food reward (see Figure 4). Both turtles correctly selected their assigned colors on more than 90% of the presentations over repeated sessions. To make the task more challenging, several shades of grey were added as potential choices. So, the turtles had to select between a random assortment of paddles of varied shades between white and black, always presented two at a time. Since Flippy was originally assigned the black paddle, he received the food reward whenever he selected the darker of the two paddles, and Mario was rewarded for picking the lighter one. The turtles did exceptionally well at this task and later worked similar tasks with arrays of blue and green paddles.

The turtle cognition sessions quickly became quite popular with visitors often staying to watch the entire session and even cheering and clapping when the turtles make correct choices. The sessions were so popular that the decision was made to move the sessions from the early morning when the area was less busy to the mid-afternoon when the area becomes quite crowded with guests. The observation windows at these afternoon sessions are full of interested visitors and the crowd is often more than six people deep, with hundreds of visitors watching all or part of a 20-minute session. As the crowds grew, the need arose to improve visibility for those guests not able to stand right up at the viewing window and so a high-definition video camera was installed and used to project the session on a large plasma screen (see Figure 3). Also, in addition to the keeper running the session explaining what was happening on the microphone system, an additional keeper was stationed outside of the window among the guests to answer questions and interpret the session. Buzz about the turtle cognition program has continued to grow around the park and it is now featured during special events such as World Turtle Day and has even been highlighted in our park's online blog (see http://disneyparks.disney.go.com/blog/2011/05/are-you-smarter-than-a-turtle-find-out-at-disneys-animal-kingdom/).

In addition to being popular with park visitors, the turtle cognition program has had a number of great benefits to the animals, the keepers, and the research staff. For the turtles, participation in cognitive research appears to be quite enriching. These tasks have provided the turtles with additional exercise and given them the opportunity to face challenges and make choices which exert control over their environments. The animal keepers enjoy participating in the research and demonstrating to guests that turtles, and reptiles in general, are capable of relatively complex problem solving. Finally, the findings of the turtle cognition research program are adding new data to the literature on the cognitive capacities of reptiles. Results have been presented at local, national, and international conferences and submitted to scientific journals.

The turtle cognition program at Disney's Animal Kingdom® continues to grow and to excite and inspire our guests. It is our hope that this program overview will encourage others working with turtles and other reptiles to develop new and creative ways to demonstrate the amazing abilities of these animals to the public. Please do not hesitate to contact any of the authors of this paper to learn more about the specifics of the turtle cognition program.

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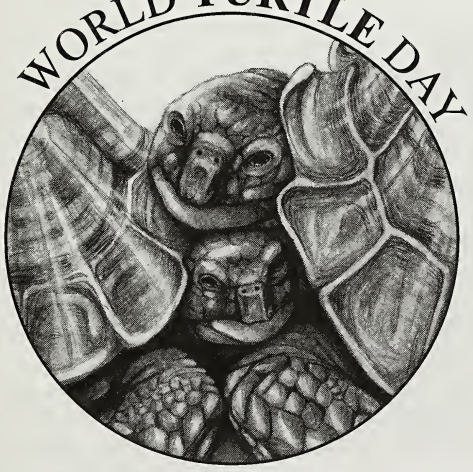

23 May 2013

"Sulcatas" by Bridget Smith, Keeper, Great Plains Zoo

The *Cuora galbinifrons* Studbook: A Model for Understanding Studbook Challenges

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Introduction

Studbooks can be effective tools for monitoring and managing captive zoo populations, particularly those of threatened or endangered species. In addition to providing useful demographic and survivorship statistics which can be used to assess and evaluate animal welfare and husbandry practices, studbooks also provide pedigrees which enable population managers to make informed decisions on selected pairings aimed at maximizing the genetic diversity within captive populations.

Due to burgeoning threats such as habitat destruction, degradation and fragmentation, and over-collection for the food trade, nearly half of the planet's turtle and tortoise species are threatened with extinction (Rhodin et al., 2011). Zoos and related institutions have played key roles in efforts to combat these threats, and frequently participate in *ex-situ* conservation breeding initiatives. According to the International Species Information System (ISIS), approximately 250 chelonian species are presently maintained within zoological institutions worldwide; many of which are listed by the IUCN as threatened or endangered. The Association of Zoos and Aquariums (AZA)-accredited zoos in North America hold more turtle species than any other region, but currently oversee studbooks for only 36 species.

The Indochinese box turtle a.k.a. flowerback box turtle (*Cuora galbinifrons*). *Photo ©Shutterstock*

Experiences with the Indochinese Box Turtle Studbook

Many challenges were experienced while updating the North American regional studbook for the Indochinese box turtle, *Cuora galbinifrons* (Lowe, 2006). As of 2006, there were 80 known specimens of the Indochinese box turtle living in captive North American collections, 31 of which were held in AZA-accredited institutions (Lowe, 2006). Today, only 30 of those original animals have been located, with 23 residing in AZA-accredited institutions.

Recent phylogenetic investigations by Stuart and Parham (2004) have revealed that specimens once identified as *Cuora galbinifrons* actually represent three distinct species: *C. galbinifrons*, *C. picturata* and *C. bouretti*. Additionally, specimens originating from Hainan Island, China are now considered a junior synonym of C. *galbinifrons* (Obst and Reimann, 1994; Lehr et al., 1998; Stuart and Parham, 2004). The previous studbook included all three species as one population, with only some individuals taxonomically identified. Accurately identifying each individual in the studbook was necessary before any data could be compiled or organized.

To positively identify animals, participants of the studbook were asked to provide three photographs depicting dorsal, ventral and lateral views of each specimen. With generous support and assistance from several turtle specialists, individuals were properly identified based on defining physical features, coloration, and markings.

Of the 80 individuals included within the previous studbook (Lowe, 2006), only 30 have been successfully tracked down to date. Additionally, 19 animals were added to the studbook; seven were acquired by institutions and 12 were successfully hatched by studbook participants. Of these individuals, 43 have been positively identified: 1.1 *C. picturata*, 1.1 *C. bouretti*, and 10.17.12 *C. galbinifrons*. Of the 10.17.12 *C. galbinifrons*, 4.7.10 have been identified as *C. galbinifrons hainanensis,* which for studbook purposes are referred to as Hainan Island intergrades (*C. galbinifrons* with *C. bouretti* influence). The decline in the number of specimens since 2006 may be due to a number of contributing factors, including animals being placed with individuals or institutions that do not wish to participate in the studbook, animals that have died, or specimens that could not be located.

Since 2006, a total of 12 offspring (all representing Hainan island intergrades) have been produced by studbook participants and added to the captive population; seven were hatched by a single private herpetoculturist, and the remaining five were produced by a single AZA-accredited institution. Several private herpetoculturists in the United States currently maintain sizeable collections of *C. galbinifrons* and *C. bouretti* and are successfully breeding them, but don't wish to participate in the studbook or disclose their identity or information for fear of having animals stolen. One particular individual maintains a collection of 10.16.15 *C. bouretti*, receives approximately 50 eggs a year from his group, and has successfully hatched a total of 19 offspring over the past four years. By comparison, one of only two North American institutions participating in the Indochinese box turtle studbook that have bred *C. galbinifrons* intergrades in the past decade, has received approximately 40 eggs from two females over the past 10 years, but has only added seven captive-bred offspring to the studbook. This not only demonstrates the advantage of inviting successful private herpetoculturists to participate in regional studbooks as a way of increasing genetic diversity and bringing in outside expertise which could help advance husbandry and reproductive management, but also highlights some of the difficulties that keepers are experiencing with breeding these species. Now, especially after being split into three distinct captive populations, some of these species are so poorly represented in AZA-accredited institutions that collaboration with responsible private herpetoculturists is almost necessary to sustain viable captive populations.

Challenges facing the compilation and management of chelonian studbooks

To better identify and understand some of the specific challenges affecting the creation, maintenance and management of chelonian studbooks, a brief survey was distributed to the 23 current AZA chelonian studbook holders. A total of 16 responses were received. Among these responses, the most frequently noted challenges included tracking down individuals, failure of participants to comply

with studbook recommendations, a general lack of cooperation from private turtle hobbyists, and the amount of time needed to compile and manage studbooks. We find that the most frustrating challenge is limited cooperation between zoos and private herpetoculturists.

Zoos may find it difficult to work together with private herpetoculturists because of the history of their relationships as well as their differences in motives, goals and resources (Murphy et al, 1997; Brackner, 1994). Due to spatial limitations and a lack of interest from other institutions, zoos may occasionally loan or gift surplus animals to private herpetoculturists. By placing turtles in private collections, zoos may be unknowingly isolating those animals from studbook populations. According to several survey responses, private hobbyists tend to be willing to accept animals from zoological institutions, but are often reluctant to give back or redistribute animals for recommended pairings.

From the information we have gathered thus far, it seems that private North American herpetoculturists have been more successful in keeping and breeding the Indochinese box turtle than AZA-accredited institutions. Given the limited number of captive representatives of many chelonian species held in North American zoos, we feel that cooperation with the private sector is needed for increasing genetic diversity and the availability of specimens for conservation breeding programs.

Private herpetoculturists must be willing to collaborate with zoological institutions by both giving and receiving animals. Additionally, when animals that are part of a studbook are placed with private individuals, it is important to ensure their continued participation with animal management recommendations. This means properly educating private herpetoculturists about their roles and responsibilities as studbook participants. Moreover, when surplussing animals, zoos should consider the long term goals for the species. Placing animals with private individuals can be beneficial and result in successful breeding, as long as the population is managed effectively.

As wild turtle populations continue to decline worldwide, the importance of chelonian studbooks as a way of managing assurance populations for potential reintroduction has never been so great. Overcoming many of the challenges discussed above will help to ensure that chelonian studbook data are successfully compiled and captive populations are managed effectively.

Benefits of managing a studbook

We should emphasize that this article is not intended to dissuade interested parties from becoming chelonian studbook holders, but instead highlight some of the challenges facing their compilation and management in an effort to better prepare new studbook keepers and interested parties for the challenging task ahead. Becoming a studbook keeper can be a rewarding endeavor, not only towards the conservation of threatened or endangered species, but on a personal level as well.

Managing a studbook can be a great opportunity to connect with other members of the herpetological community. The backgrounds of individuals working with turtles are vast, from academics to zoo professionals to private herpetoculturists. Corresponding with individuals working with your species at both the professional and hobbyist levels can offer new insights into their biology, captive husbandry, and reproduction. Keepers who are developing chelonian studbooks should make every effort to attend professional symposia and conferences, as these events are usually attended by turtle biologists, husbandry professionals and private herpetoculturists, and allow for further networking opportunities and informational exchanges.

Becoming a studbook keeper is an excellent way to become knowledgeable about a particular species or taxonomic group of interest. Through research and collaboration with other professionals and hobbyists, studbook keepers often accumulate vast amounts of information and literature relevant to a particular taxon and are consulted by zoo professionals and private hobbyists as important sources of information. Sharing and disseminating this information with others is an essential part of a studbook keeper's duties which can help improve standards of husbandry and reproductive management.

Lastly, this paper hopes to persuade animal husbandry professionals to reach outside of their species of preference, and consider managing a chelonian studbook. Although having a passion for chelonians and sufficient knowledge of their biology and captive maintenance is beneficial when managing a studbook, having strong organizational and time management skills are equally as important.

Acknowledgements
We would like to thank the following chelonian studbook keepers for their comments and constructive feedback: Diane Barber, Brad Poynter, Rick Haeffner, Michael Ogle, Bill Hughes, Beth Moorhead, Craig Pelke, Steve Gott, Richard Rosevear, Jeff Jundt, Vance Alford, Megan Baumer, Ed Louis, Sarah Plesuk and Barry Downer. Lauren Augustine would like to thank Dwight Lawson, Heather Lowe, Ray Farrell, Uwe Fritz, Penny Felski, Brad Lock, Erich Krausse and Rick Hudson for their time, expertise and assistance with this studbook. Lastly we would like to thank Jim B. Murphy and Kenton Kerns for their comments on an earlier draft of this manuscript.

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Surgery and Rehabilitation on a Male Painted Terrapin (*Batagur borneoensis*)

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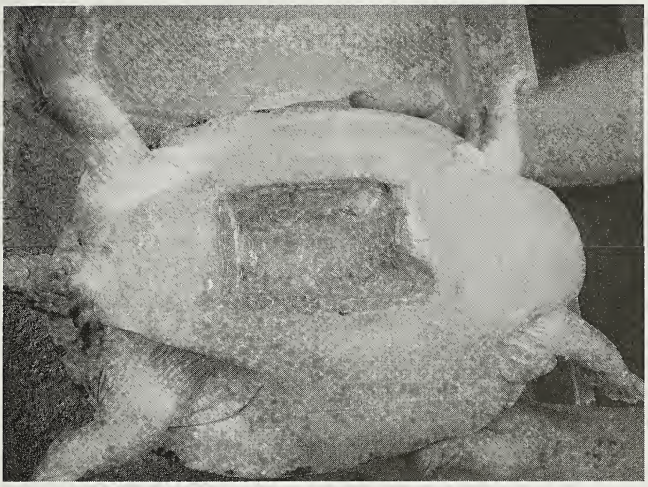
Downtown Aquarium Denver
Denver, CO

The painted terrapin (*Batagur borneoensis)* is a freshwater turtle found in mangrove swamps and estuaries of large rivers in Malaysia and Indonesia and feeds primarily on fruits and leaves of mangroves. Adults show sexual dimorphism, with females being larger than males and during the breeding season the head of the male turns white with a red stripe between the eyes. Breeding occurs one to two times per season, which is usually between June and February, depending on the area, and each clutch contains anywhere from 10-15 eggs. Female painted terrapins usually travel to nest on the same ocean beaches that are frequented by green sea turtles. Human consumption of eggs and the meat of adults, collection for the pet trade and loss of habitat have led to a serious decline in numbers and this species is classified as Critically Endangered on the IUCN Red List and is included in CITES Appendix II. Also, according to the Turtle Conservation Coalition, painted terrapins are #25 on the list of the world's most endangered tortoises and freshwater turtles. □

Lovebug, the painted terrapin (*Batagur borneoensis)*

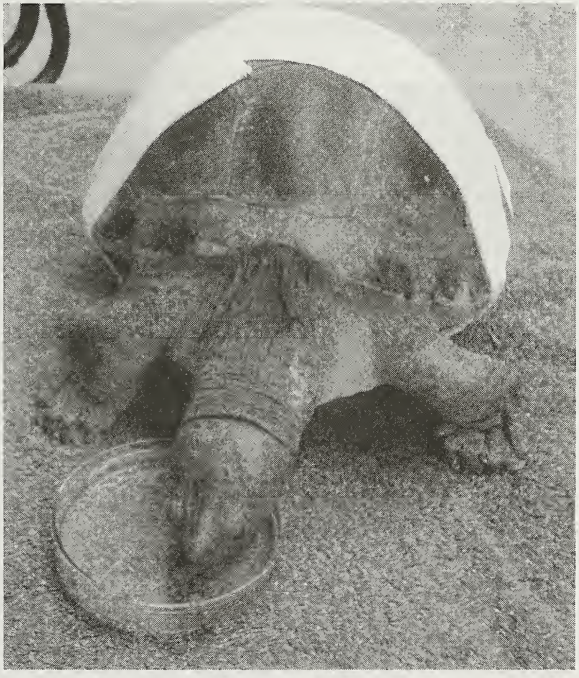
The Downtown Aquarium Denver exhibits three male painted terrapins. In March, 2011, one of them presented with abnormal symptoms which included positive buoyancy, excessive hauling-out behavior and inappetance. A radiograph was performed showing an impacted bowel which could only be resolved through surgery. Our veterinary staff, led by Dr. Terry Campbell, an exotic animal specialist with the Colorado State University's Veterinary Teaching Hospital performed the surgery which involved cutting out a section of his plastron to obtain access to the bowel to remove the impaction. In preparation for surgery, the terrapin was put on a ventilator with a gas anesthetic and a Doppler device was tucked into the opening of his shell to monitor his heart rate. An oscillating saw was used to cut out about a 4"x3" portion of his plastron to gain access to the bowel. The material causing the impaction was removed, the bowel was sewn back up and the plastron was replaced, sealed with mesh and secured with epoxy. He successfully made it through surgery and was returned to his exhibit.

In June, 2011, during one of his follow-up physicals, it was noted that the section of his plastron that had been removed was not adhering properly and he was suffering from a serious infection that could have been fatal. Another procedure would need to be performed to debride the area to remove the infection and the necrotic tissue. This procedure was risky because his condition was guarded and he would have to be anesthetized which always involves a certain amount of risk. He was returned to CSU Veterinary Teaching Hospital and was prepped for surgery for a second time. He was anesthetized, placed in a dorsal recumbent position and the necrotic portion of the plastron was removed and discarded. The wound was prepped with betadine and the surrounding plastron



The wound viewed through the plastron.

was prepped with chlorhexidine. The soft tissue along the edges of the plastron was scraped away by using a periosteal elevator, the purulent material from the underlying peritoneum was removed using a #10 blade and the sutures from the previous surgery were removed. Luckily, the peritoneum was found to be intact indicating that the infection had not penetrated the coelemic cavity. A Brasseler air drill with a 5mm round burr was used to debride the bone edges until healthy, bleeding bone was exposed. Once gross debridement was complete, the wound was lavaged with two liters of sterile saline. Although the surgery went well and he recovered from anesthesia with no complications, he was still not out of the woods. The infection had not been completely removed and the tissue would need time to granulate. In order to promote the healing process, he would need ceftazidime injections every three days for a total of 10 treatments and would need bandage changes twice a day, everyday, using the wet to dry method. This procedure involves soaking sterile gauze in sterile saline solution and applying directly to the wound area, then packing the area with dry gauze, securing with elasticon tape and finally securely wrapping him in vet wrap to prevent the tape from coming off when he would move. Also, to maintain a completely sterile environment, it was important to wear sterile gloves to avoid introducing any new infections to the area. The concept behind this type of bandage is that when the wet gauze dries, the exudate adheres to it and is removed from the area. Another concern was ensuring that the wound stayed dry which meant that he would have to be out of the water for an extended period of time. Since painted terrapins are semi-aquatic turtles and spend the majority of their time in the water, only coming out to bask and lay their eggs, we were not sure what kind of effect this would have on his overall health. Unfortunately, it was a risk we would have to take. The decision was made that his best chance for recovery would be continuous care. We felt that leaving him at the aquarium without supervision would be detrimental to his health and we decided that someone should take him home to ensure he was getting the most thorough care possible.



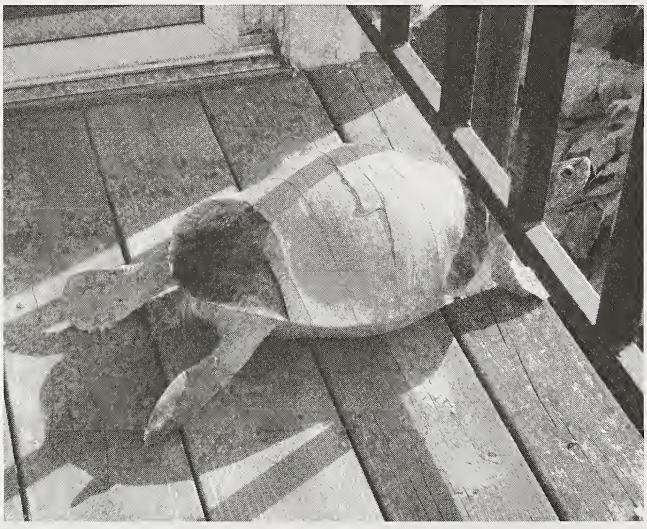
Drinking from a petri dish

Unfortunately, he was still very sick and weak and was not interested

Special bowl for drinking water and diet presentation

in drinking any water which was concerning because we needed to prevent dehydration. In order to get him some water, a syringe was used to spray water directly into his mouth. It was about a month before he showed any interest in drinking on his own. Finally, he started drinking out of a small Petri dish, but we needed to find a way to get more water into his system. We constructed a special bowl which allowed him to drink as much water as he wanted but prevented his wound from getting wet. The basic concept was a shallow, rectangular plastic container with an elevated padded area for him to sit on and a bowl of water placed level with the padded area near his head so he was able submerge his head directly in the bowl and drink the water.

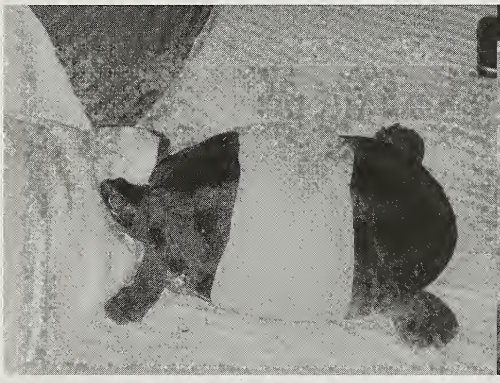
Now that he was drinking on his own, the next step was to get him to eat. Even though he is a reptile and can go without food for an extended period of time, we knew that getting him a balanced diet would aid in his healing. Calcium is an essential mineral that turtles need in order for them to build a healthy shell. In their natural habitat, juvenile painted terrapins are considered to be omnivorous, eating both plant and animal material which allows them to get the calcium they need to grow. As they reach adulthood, they become more herbivorous, eating mainly vegetation. Since he had a shell injury, we needed to make sure that he was getting enough calcium to help his shell heal and grow. We also needed to make sure that we monitored his diet because we needed to avoid a diet high in phosphorous which would prevent proper calcium absorption. We came up with a varied diet to try which included shellfish, specifically shrimp and clam, leafy greens, like kale and romaine and a variety of other fruits and vegetables, which included cantaloupe, watermelon, mango, berries, carrots, green pepper, squash and cucumber. We felt that the key to a healthy diet was variety. We knew that he would readily drink out of his special bowl but we were not sure if he would also eat out of it since he needed water to swallow his food. So food was added to the bowl while he was drinking and after investigating the food for a bit, he finally started eating it. Eventually it got to the point where he did not even want to drink much water if there was no food available. This was a great sign and we knew he was definitely starting to heal.



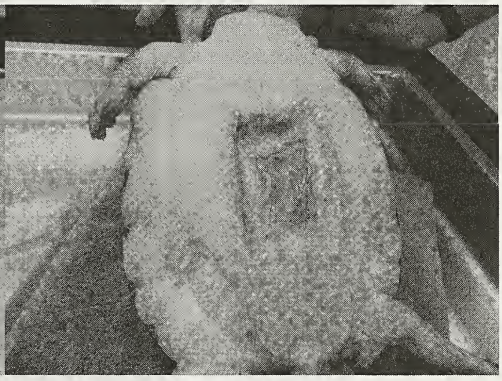
Basking on the balcony

Now that he was drinking and eating regularly, we needed to ensure that he was getting everything else he needed to promote healing. Suitable lighting is essential to the health and growth of turtles and plays a key role in the production of Vitamin D_3 which is an essential vitamin that ensures the proper metabolism and absorption of calcium. Insufficient Vitamin D_3 levels can lead to Metabolic Bone Disease (MBD) which causes softening and deformities of the shell and can be fatal. Luckily, he was recuperating during the summer months which allowed him to bask as often as he wanted on a balcony in the direct sunlight and soak up necessary ultraviolet rays. Since he is a cold blooded animal, being out in colder weather would have been detrimental to his health. So on the colder, cloudier days he was not able to bask but we still wanted him to have the full spectrum of necessary ultraviolet light. In order to accomplish this, an area was set up that included a UVB bulb and a heat lamp which he adapted to very quickly.

We also needed to ensure that he was getting the necessary rest that his body required to promote healing. Being an aquatic turtle, his normal routine would include things like swimming, basking



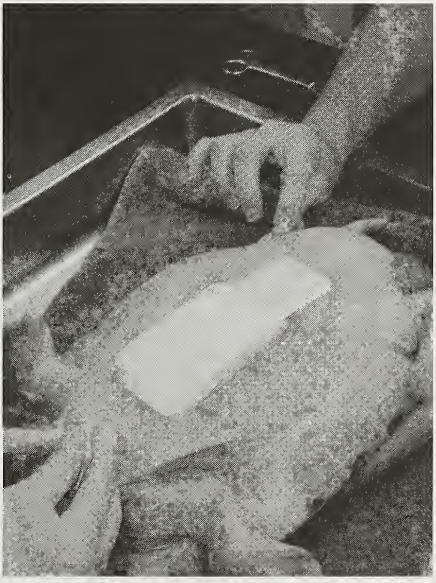
Sleeping in style: blanket, pillow, UVB...



Inspection of the wound

and sleeping underwater. Unfortunately, he was not able to go into the water and we were not sure what the best option would be. Not wanting to be accused of too much anthropomorphizing, we decided that we just needed to make him an area where he would feel secure enough to rest. So we laid down blankets and a pillow under his UVB and heat lamp and he quickly adapted to this as well and now was not only basking under the lamps but was also sleeping under them. Another issue that arose during his time out of the water was that his shell and skin were not staying well-hydrated; although he was being misted regularly, they were becoming dry and cracked. In order to combat this problem, we decided that a natural emollient might help with hydration. We opted to try bag balm which is a salve that was developed for use on cow udders. Fortunately it worked great and, with continued applications, his shell and skin started to heal up and regain moisture.

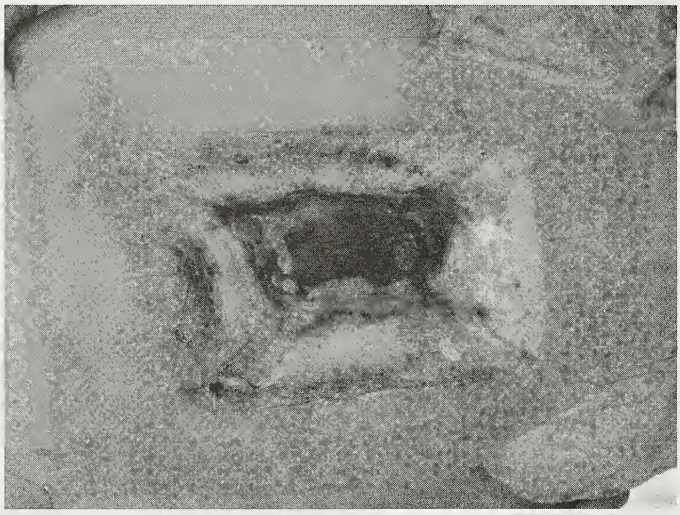
After about a month, his wound was starting to heal and his health was returning to normal so we decided that we could reduce the need for bandage changes to



Tegaderm® is a "waterproof" dressing

once a day. After a couple more months, we decided that since his wound was continuing to heal, we would only change the bandage 2-3 times per week in order to reduce stress on him since he had to be on his back for the duration which is not a natural position and causes breathing difficulties. Also, one of the downsides to using wet to dry bandages is that the gauze will not only remove exudate but will also remove healthy granulation tissue which is counterproductive. We had to come up with a new plan to continue the healing process as well as find a way to get him back into the water.

After about another month, we decided to discontinue using the wet to dry bandages and instead began using a sterile foam dressing to protect the wound area and a waterproof but breathable transparent occlusive medical dressing called Tegaderm® to adhere to and cover the area. The process involved applying the foam directly to the wound and using superglue to secure the Tegaderm® to the area of the plastron surrounding the wound. After quite a bit of drying time, he was introduced back into the water. Unfortunately, after being in the water for a couple of hours, we checked on him and found that water had seeped under the Tegaderm® and was in contact with the wound area. We tried a few different techniques when applying the Tegaderm® and he was able to spend a bit more time in the water. But it continued to leak and we knew that this was not the best option and we needed to come up with another plan. We decided to continue with the wet to dry bandages in the event that the little bit of water that had come in to contact with the wound area had caused any issues.



A view of the wound during treatment.

Although we had returned to using the wet to dry bandages, we knew we had to devise a better plan of action because, as mentioned, this type of system would remove unhealthy tissue but it would also remove healthy tissue. After some research, we found reported cases of the successful use of medical grade honey in sea turtle wound treatment and rehabilitation at the Georgia Sea Turtle Center in Jekyll Island, GA. For centuries, honey has been known for its healing properties and has been used to treat wounds, burns and ulcers in humans. It creates a moist healing environment, prevents the growth of bacteria and unlike other wound dressings, does not cause damage and instead promotes granulation and epithelialization. This was exactly the option we were looking for and made the decision to try this as our new wound dressing for him. We chose to use Medihoney® 4"x5" wound dressings manufactured by DermaSciences, Inc., which are composed of active leptostermum honey indigenous to New Zealand. Each dressing costs anywhere from $10-15 per dressing, so not an inexpensive option since we were not sure if it would work and if it did work, how often it would need to be changed.

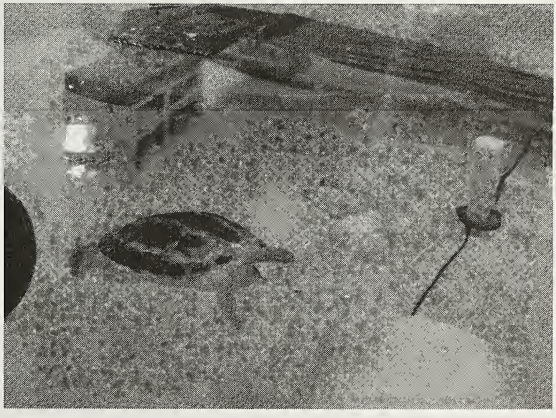
The process of changing the bandage had remained basically the same with the exception of substituting the honey dressing for the wet gauze. We still needed to pack the area with dry gauze so the honey dressing would conform to the wound, tape over the gauze with elasticon and wrap him in vet wrap, so still a stressful process. Since we were not certain how the Medihoney® would work, we decided to replace it after a couple of days. The first time we removed the bandage we were pleased to see that it had quickly and effectively started to heal the area and there appeared to be a small

The wound showing progress from treatment

amount of granulation even after the first application. We knew we still needed to figure out a way to get him back in the water but at least we were making progress and he was a little less stressed. As always, he seemed to adapt well to everything and continued to do all the things he had been doing like basking, sleeping, drinking and eating.

During this entire process, we had been drawing blood on him to monitor his blood values, making sure no issues were arising. The results from the most recent blood draw showed a sharp increase in his BUN (blood urea nitrogen) level from 7mg/dL to 35 mg/dL over a five-month period. Although there has been some debate over whether or not BUN levels were a good indication of kidney issues and possible kidney failure in reptiles, we decided that the increase was concerning and could be a possible indication of dehydration, which was a strong possibility since he had been out of the water for an extended period of time. But we were also still concerned that the wound had not healed sufficiently and would be re-infected if exposed to water. The decision was made to continue for another few weeks using the Medihoney® and re-evaluate at that point. After a couple of weeks and a few more bandage changes we were satisfied with the progress he was making and made the decision that it was time for him to be returned to the water without the use of any bandage.

The Downtown Aquarium has a separate quarantine facility and we introduced him back into the water in one of our 12' round quarantine tanks so he could be observed and monitored closely. We set the tank up with the necessary UVB light and heat lamp and an area which consisted of a padded haul out for him to bask and sleep on and a ramp for him to use to climb onto the haul out. We routinely checked on the progress of the wound and noted continuous tissue granulation and bone growth. This was a positive outcome and indicated that being back in the water would not cause any wound regression and would not be detrimental to the healing process. Although his wound was healing, it was a slow process and he would have to be housed in quarantine for an extended period of time. We did not think he was ready to return to exhibit because his wound still had some exposed soft tissue and we did not want to risk the possibility of damage to the area. Our Asian Turtle exhibit houses other turtle species, small fish and jagged rocks, any of which could possibly cause damage. So he would continue to be housed in quarantine for the time being.

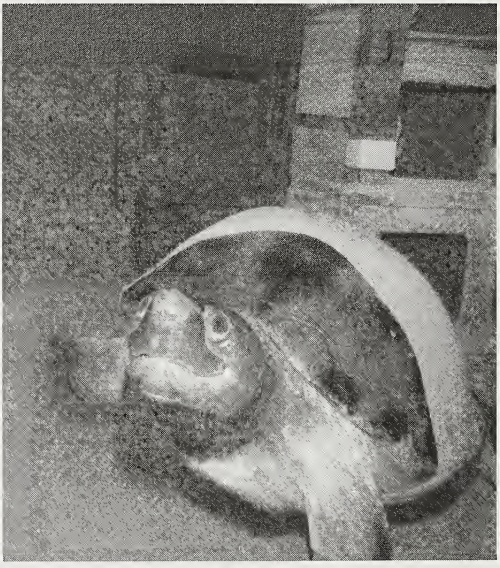


Lovebug enjoying his enrichment feeder ball

On one occasion, while doing some routine maintenance in the tank we noticed that there were some bite marks on the foam padding that we were using for his haul out area. We removed the foam and replaced it with hard plastic mesh that he would be unable to chew on but would still be appropriate to haul out on. Thinking about reasons why

he might be doing this, we came up with the idea to offer him enrichment items to provide some environmental stimulation. His tank housed about 1,400 gallons of water, approximately 20" deep, with a haul out area and a Rubbermaid® container all comprising about 25% of the tank. He did spend a lot of time on the ramp and often slept on top of the container, but we felt he would benefit from some other possible enrichment items. As one of the items, we chose three 10" diameter sections of PVC pipe cut about 12" long that he could use to rest on, swim through or possibly push around the tank. We knew that he was very food motivated so we decided to revolve other enrichment items around food. We obtained a small hard plastic ball and drilled varying sized holes in it and would fill the holes with kale or romaine. The final item we decided on was ice food where we basically made ice cubes with frozen vegetables and seafood inside.

The first enrichment we tried was the PVC sections and at first he avoided them but he eventually began investigating them and was observed resting his front limbs on them and swimming through them on occasion. He was never observed pushing them around the tank which may be because they are quite heavy. The second enrichment item that was introduced was the feeder ball with leaves of romaine stuck into the various holes and as soon as it was put in the water he was trying to grab it. With this particular item, he would grab on to the romaine and bring it to the bottom of the tank and bite a piece off. At this point, the ball would shoot to the surface and he would have to ascend and retrieve it and he would do this until all visible pieces of romaine had been eaten. After eating all the visible pieces, he seemed to know that there was more inside and would continue to push the ball around to try and get it at. The next enrichment item we offered was ice food. We first made small-size ice cubes and as soon as we put it in the tank he grabbed at them. After a couple of attempts, he was able to grab the ice cube and bring it to the bottom. At this point, since the ice cube was small and the temperature of the tank was at 80°F, it had significantly melted and he would just swallow the whole thing, thus not getting much enrichment. We decided to make much larger ice cubes and this worked out much better. He was still able to grab the ice cube and descend with it but was unable to swallow it immediately. Instead he had to keep ascending to retrieve it and also hunt for it as it kept floating away. Overall, we felt that we had been successful with the enrichment items and going forward, had not noticed any unwanted or stereotypical behavior on his part. This was a positive outcome as we knew that he would most likely be housed in this tank for quite a few months while the healing process continued.



Lovebug, the painted terrapin, ultimately recovered from surgery

It has been almost a year since his surgery and after all the hard work and dedication by the entire Life Sciences and Life Support departments at the Downtown Aquarium Denver, our male painted terrapin is doing exceptionally well and will soon be returned to the Asian Turtle exhibit so guests can come and visit him.

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